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Proceedings of the Fourth Meeting

OF THE

LIBRARY
OF THE
UNIVERSITY OF ILLINOIS.

Illinois Water Supply Association

HELD AT

THE UNIVERSITY OF ILLINOIS
March 5 and 6, 1912

Published by the Society

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SECOND VICE-PRESIDENT—H. M. Ely, Superintendent Water Co., Danville.

THIRD VICE-PRESIDENT—W. J. Spaulding, Commissioner of Public Property, Springfield.

SECRETARY-TREASURER—Edward Bartow, Director State Water Survey, University of Illinois, Urbana.

COMMITTEES.

EXECUTIVE—

The officers and Past President Owen T. Smith, Superintendent and Secretary Freeport Water Company, Freeport.

RELATIONS WITH THE STATE BOARD OF HEALTH, STATE WATER SURVEY AND THE ENGINEERING EXPERIMENT STATION OF THE UNIVERSITY OF ILLINOIS.

H. M. ELY, Superintendent Danville Water Co., Danville.

W. C. PARK, M. D., Health Commissioner, Rockford.

C. B. BURDICK, Consulting Engineer, 1417 Hartford Bldg., Chicago.

L. PEARSE, Division Engineer, Sanitary District of Chicago, Chicago.

E. P. WHEELER, Superintendent Water Company, Lake Forest.

LEGISLATION—

F. C. Amsbary, President and Manager Champaign and Urbana Water Company, Champaign.

H. B. Morgan, Managing Director Peoria Water Works Co., Peoria.

W. J. Spaulding, Commissioner of Public Property, Springfield.

PUBLICATIONS—

A. N. Talbot, Professor Municipal and Sanitary Engineering, University of Illinois, Urbana.

T. W. Gannon, Superintendent Water Company, Cairo.

Edward Bartow, Director State Water Survey, University of Illinois, Urbana.

EXHIBITS—

H. W. Clark, President and General Manager Mattoon Clear Water Company, Mattoon.

G. C. Habermeyer, Associate Municipal and Sanitary Engineering, University of Illinois, Urbana.

W. A. Start, Neptune Meter Co., 914 First National Bank Building, Chicago.

PROGRAM—

The President and Secretary ex-officio.

E. MacDonald, Superintendent Lincoln Water & Light Co., Lincoln.

W. Lee Lewis, Instructor in Chemistry, Northwestern University, City Chemist, Evanston.

Paul Hansen, Engineer, Illinois State Water Survey, Urbana.

MINUTES OF THE FOURTH MEETING OF THE ILLINOIS WATER SUPPLY ASSOCIATION.

The fourth meeting of the Illinois Water Supply Association was called to order by President Smith at 10 A. M. Tuesday, March 5, 1912, in the Lecture Room of Engineering Hall of the University of Illinois. President Smith delivered the annual address. The recommendations made were referred to a committee consisting of Messrs. W. J. Spaulding, W. J. McGonigale and George Irving for consideration and report at a later session. This committee at a subsequent session reported as follows:

"MR. CHAIRMAN:—Your committee, appointed to consider the advisability of changing the meeting place of this Association from the University to such other cities as might be selected from time to time, beg leave to report in favor of continuing the meetings here.

GEO. IRVING.
W. J. MCGONIGALE.
W. J. SPAULDING.
Committee."

The Secretary-Treasurer's report was then presented.

SECRETARY-TREASURER'S REPORT.

An increase in the number of members has continued throughout the past year. The interest taken in the Association is encouraging. The following table shows the members and associates at the time of each meeting:

	First year	Second year	Third year	Fourth year
Members	37	116	158	183
Associates	1	13	19	24

There were 37 persons registered at the conference at which the Association was organized. This number does not represent the full membership at that time as several others had expressed their intention of joining the organization. During the past year 44 new members have been elected; three members have died; nine have resigned and

seven have been dropped for non-payment of dues, leaving a net membership of 183. Seven associates have been elected, one has resigned, and one has been dropped, leaving a net associate membership of 24.

The Proceedings of the third meeting have been edited and published. One thousand copies were printed including 250 copies bound in cloth for members, associates and advertisers. Paper bound copies have been sent as exchange to the Illinois Society of Engineers and Surveyors, the Indiana Water Supply Association and the Wisconsin Engineering Society. The Proceedings of these Societies have been sent to the members who have paid the 1911 dues. Unless instructed to the contrary the Secretary will try to arrange the same exchanges for the coming year.

The Proceedings were issued at a late date owing to certain matters connected with the State Water Survey that required all of the attention of the Secretary immediately after the last meeting. This year arrangements have already been made with the printer to have the work of printing begun April 1st and to have the Proceedings issued in 60 days thereafter. Material not ready in time will be omitted.

Advertising contracts are being received and more than two-thirds of last year's contracts are already renewed. It is hoped that there may be an increase in the amount of advertising in the coming Proceedings though the short time remaining before the Proceedings go to press may limit the quantity obtained.

Owing to the unexpectedly large amount of unpaid bills for dues and advertising show in the last report of the Secretary-Treasurer it was necessary to economize somewhat during the past year. It was not thought possible to furnish reprints to authors free and only 1000 instead of 1250 copies of the Proceedings were printed. From these and other economies there is an actual balance in the treasury. This balance does not include the 1912 dues which should be reserved for the expenses following the 1912 meeting. While there was an apparent balance in the last report there was an actual deficit. Enough of the unpaid dues and all the unpaid advertising has been collected, making up the deficit. The rest of the unpaid dues for 1910 has been marked off as uncollectable and it is not included in the statement concerning unpaid dues and advertising in this year's summary.

FINANCIAL STATEMENT.

Balance		$ 35.26
RECEIPTS—		
Initiation fees—		
Members	$ 38.00	
Associates	30.00	
Dues, Members 1910	22.00	
Members 1911	262.00	
Dues, Associates 1910	10.00	
Associates 1911	80.00	
Advertising, 1910	20.00	
1911	285.50	
Reprints	52.63	
Sales of Proceedings	6.15	
Income, 1911	$ 806.28	
Total		$841.54
EXPENDITURES—		
Postage	$ 74.96	
Express	51.53	
Freight	2.43	
Printing	30.00	
Duplicating	3.96	
Engravings, half tones and etchings	36.12	
Stenographic and clerical work	50.00	
Printing Proceedings	390.81	
Reprints	66.01	
Total	$ 705.82	
Unpaid dues and advertising, 1911	99.00	$804.82
Balance, March 4, 1912		36.72
Dues, 1912 members	88.00	
Associates	35.00	
Dues, members 1913	2.00	
	$ 125.00	
Balance, March 4, 1912		$161.72

The Secretary urges each member to make himself a committee of one to promote the welfare of the Association and would suggest the following lines of action:

First: Look over the list of members in the Association and note where there are cities without representation. Use your influence to

obtain representatives in these cities. We need representatives in every city in the state.

Second: Patronize our advertisers and point out to your supply houses, if they are not advertisers, the advantages of the Association. We need more advertising.

Third: Make careful notes of any improvements in equipment or methods of operation and be ready to inform the Association of the results in a brief paper to be presented at the next meeting.

The Secretary wishes to thank the members for the assistance rendered during the past year.

Signed:

EDWARD BARTOW,
Secretary-Treasurer.

The Chairman appointed Messrs. C. R. Henderson, D. H. Maury, and F. M. Sinsabaugh, as a committee to consider the Secretary's report, and audit the accounts. The committee later presented the following report:

March 5th, 1912.

Illinois Water Supply Assn.,

GENTLEMEN:

Your committee begs leave to report as follows: Pursuant to instructions we have audited the books and accounts of the Secretary-Treasurer, and we find the same correct.

The Secretary is to be congratulated upon the continued growth in its membership, the unusual excellence of its program, and the economical, efficient, and business-like manner in which its affairs have been conducted. For all these things the credit is due to the Secretary-Treasurer.

Your committee would heartily indorse the recommendation of the Secretary-Treasurer embodied in his official report; and would earnestly urge every member to co-operate with him to accomplish the results aimed at in his recommendations.

Your committee would also recommend that the action of the Secretary-Treasurer in dropping from the rolls members still delinquent in payment of dues for 1910, be confirmed by the Association.

Respectfully submitted,

C. R. HENDERSON.
DABNEY H. MAURY.
F. M. SINSABAUGH.
Committee."

F. C. Ambsary, Chairman of the Committee on Legislation, reported as follows: "I have very little to say. The committee looked up the bill appropriating additional funds for the use of the State Water Survey. The committee did some good work which is attested by the results. While the whole amount asked for was not granted, a very material increase in the funds of the Survey was obtained. This was not done without a great deal of work on the part of the committee and friends."

H. E. Keeler, Chairman of the Program Committee, reported as follows: "I did not understand that I was Chairman of this committee in time to be of any particular service but I am able to report that the program meets with satisfaction. Much credit is to be given to our Secretary for the preparation of the program."

There were no reports by other committees.

E. MacDonald, Superintendent of the Lincoln Water and Light Company, read a paper entitled "Pumping by Steam and Electricity." It was discussed by Messrs. Maury and Cumming.

R. R. Parkin, Chief Engineer of the Water Department, Elgin, read a paper entitled "Does the Water Meter Increase Revenue, Reduce Consumption, and Satisfy the Consumer?" and H. Ruthrauff, Commissioner of Public Property, Decatur, read a paper entitled "Effect of Installing Meters at Decatur." These papers were discussed by Messrs. Maury, Allen, MacDonald, Irving, Trow, Ambsary, Smith, and DeBerard.

Edward Bartow, Director of the State Water Survey, made a statement concerning the "New Work of the State Water Survey." ADJOURNED.

The second session was called to order at 2 P. M. by President Smith.

Dow R. Gwinn, Superintendent of the Terre Haute Water Company, read a paper entitled "Method of Keeping Track of the Examination and Flushing of Fire Hydrants." This paper was discussed by Mr. Maury.

Paul Hansen, Engineer of the State Water Survey, read a paper entitled "Limitation of Streams Pollution."

W. J. Spaulding, Commissioner of Public Property, Springfield, read a paper entitled "Water Department Methods". It was discussed by Messrs. Lewis, F. C. Jordan, Orvis, Gwinn, McGonigale, O. T. Smith, Parkin, and Allen.

Mr. W. O. Collins, Vice-President of the Gulick-Henderson Company, Chicago, read a paper entitled, "Purchase of Coal in Accord-

ance with Specifications. It was discussed by Messrs. Cumming, Allen, Talbot, Spaulding, Orvis, and W. F. Anderson.

W. F. Monfort, Chemist Water Department, St. Louis, Mo., read a paper entitled "Color in Mississippi river water." It was discussed by Mr. Ely.

S. W. Parr, Professor of Applied Chemistry, University of Illinois, read a paper entitled "Storage of Coal." It was discussed by Messrs. Jahns, Hansen, Maury and Cumming.

Mr. L. C. Trow, Chief Engineer Water Company, Lake Forest, read a paper entitled "Anchor Ice." It was discussed by Messrs. Hansen, Orvis, Keeler, Gwinn, DeBerard, Jahns and Parkin.

Owing to the absence of the author, the paper of W. M. Cobleigh, Professor of Chemistry, Montana State College, Bozeman, Montana, was read by title. ADJOURNED.

The Annual dinner was held in the Cafe of the Y. M. C. A. Building at 7 P. M. Covers were laid for eighty.

The third session was called to order at 8:30 P. M. by President Smith.

Dr. A. J. McLaughlin, Surgeon, United States Public Health and Marine Hospital Service, Washington, D. C., gave an address entitled "The Necessity for Safe Water Supplies in the Control of Typhoid Fever". It was discussed by Messrs. Hansen, Orvis, Jennings, Bartow, Norbury, Harris, Henderson, Spaulding, and Park.

Mr. R. A. Gabbert, President Chamber of Commerce, Mattoon, read a paper entitled "Typhoid Fever and the Water Supply of Mattoon."

Mr. H. N. Parker, Bacteriologist, University of Illinois, read a paper entitled "Characteristics of Typhoid Fever Outbreaks." It was discussed by Messrs. O. T. Smith, Spaulding, Norbury, Hansen, and Park. ADJOURNED.

The fourth session was called to order by President Smith at 9:30 A. M. Wednesday, March 6th, 1912.

The report of the committee appointed to consider the Secretary's report and audit the accounts was given by Mr. Maury in the absence of the Chairman, Mr. Henderson. (It is published with the report of the Secretary-Treasurer). The report was adopted.

Dr. Arthur Lederer, Chemist and Bacteriologist of the Sanitary District of Chicago, read a paper by himself and Frank Bachmann, Chemist of the Sanitary District, entitled "Some Interesting Observations on the Disinfection of Lake Water with Calcium Hypochlorite". It was discussed by Messrs. O. T. Smith, Trow, Hansen and Park.

Dr. W. Lee Lewis, Professor of Chemistry, Northwestern University, Evanston, read a paper entitled "Hypochlorite Sterilisation of Lake Michigan Water at Evanston". It was discussed by Messrs. Lederer, Spaulding, Hansen, Ford, Burdick, Jennings, Orvis, Maury, Clark, Monfort, Allen and Jahns.

The paper entitled "Hypochlorite Sterilization and Typhoid Fever at Kansas City, Missouri", by Dr. W. M. Cross, City Chemist, was read in abstract by the Secretary.

Hon. John M. Keefer, Mayor, Macomb, read a paper entitled "Installation and Successful Operation of a Million Gallon Gravity Filter Plant."

Mr. W. W. DeBerard, Western Editor, Engineering Record, Chicago, gave an illustrated paper entitled "Filter Plants." These papers were discussed at a later session by Messrs. Bartow and Jahns. ADJOURNED.

The Fifth session was called to order at 2 P. M. by President Smith.

After the discussion of Mr. Keefer's paper the report of the committee to whom was referred the President's Address was received and adopted.

Officers were elected as follows:

President, R. R. Parkin, Chief Engineer Water Department, Elgin.

First Vice-Pres., C. H. Cobb, Superintendent Water Co., Kankakee.

Second Vice-Pres., H. M. Ely, Superintendent Water Co., Danville.

Third Vice-Pres., W. J. Spaulding, Commissioner of Public Property, Springfield.

Secretary-Treasurer, Edward Bartow, Director State Water Survey, Urbana.

President Parkin was called on, and responded briefly as follows:

Mr. Parkin: I am not much of a speech maker. I belong to the Illinois Water Supply Association and also to the American Water Works Association. When I joined the latter I had a full head of hair. By the looks of the top of Dr. Bartow's head, the Illinois Water Supply Association is bringing him into our class. I thank you very much. I will certainly do the best I can. If there is anything I can do for any city water works, whether it be under private or municipal ownership, I will try to help in any way that I can either by a visit or through correspondence and you need not be afraid to call upon me.

In the absence of Senator John N. Dailey of Peoria, the Chairman of the Legislative Committee on Public Utilities Commission, Hon. William P. Holaday, Secretary of the committee, a representative in the 47the General Assembly of the State of Illinois, addressed the Association on "Illinois Legislation on Public Utilities Commission."

A vote of thanks was given to Mr. Holaday, and it was voted that the President-Elect appoint a special committee to confer with the Legislative Committee on Public Utilities and, also, to take such action as they may deem necessary before the committee of the Legislature to whom bills on the subject may be referred.

President-Elect Parkin appointed the following members to serve on this committee: F. C. Amsbary, Chairman; C. B. Burdick, John E. Ericson, L. O. Jahns, E. MacDonald, H. B. Morgan, L. V. Orvis, O. T. Smith, and W. J. Spaulding.

Mr. M. M. Symons, Chief Engineer of the Danville Water Company, read a paper entitled "Trials and Troubles of the Pumping Station, and their Remedy." It was discussed by Messrs. Gwinn, Sinsabaugh, and Hansen.

Prof. A. N. Talbot, Professor of Municipal and Sanitary Engineering, University of Illinois, read a paper entitled, "Further Tests on the Removal of Iron from a Drift Well Water." It was discussed by Messrs. Jennings, Burdick, DeBerard and Stromquist.

Mr. F. M. Sinsabaugh, General Manager of the Citizens Gas, Electric and Heating Company, Mount Vernon, read a paper entitled, "Incrustation in Water Mains at Mount Vernon," and Mr. H. P. Corson, Chemist, Illinois State Water Survey, read a paper entitled "Composition of the Incrustation of the Mount Vernon Water System." These papers were discussed by Messrs. Monfort, Ely, and Parkin.

Dr. E. Bartow, Director, Illinois State Water Survey, read a paper entitled "Sanitary Survey of Mississippi River at Moline." It was discussed by Messrs. Hills, Jennings, Jahns, Gerber, and Monfort.

Prof. B. R. Rickards of the University of Illinois, read the paper by Dr. H. W. Hill, Director Division of Epidemiology, Minnesota State Board of Health, Minneapolis, entitled, "The Detailed Procedures for Epidemiological Investigation for Typhoid Fever." It was discussed by Messrs. Monfort, Gwinn, and Rickards.

Owing to the absence of the authors the following papers were read by title:

"Deep Wells, Joliet", H. A. Stevens, City Engineer, Joliet.

"Artesian Wells of Western Kansas", C. C. Young, Chemist Kansas State Water Survey, Lawrence.

"Purification of Water at Tulsa, Oklahoma", B. H. Sands, Superintendent Water Works, Tulsa.

A vote of thanks was tendered the retiring President and all the officers for the interest they have taken in the Association.

Mr. William G. Clark of Toledo, Ohio, in support of this motion spoke as follows: "I have attended meetings of Associations in different places, but have never attended a meeting more successfully carried out than this has been, and it seems to me that the carrying out of this program, and as near to the program as it has been, has been a work of art." ADJOURNED.

The Register for the 1912 meeting contains the following names:

MEMBERS.

Allen, Amsbary, Anderson W. F., Bachmann, Balderston, Barnes, Bartow, Bernreuter, Bryant, Burdick, Carson, Clark W. G., Cobb, Corson, Culver, Cumming, Davidson, DeBerard, Dechman, Drake, Ely, Enger, Gabbert, Goss, Gough, Gwinn, Habermeyer, Hansen, Henderson, Hilscher, Huggans, Jahns, Jennings, Johnson C. T. E., Keeler, Landon, Langelier, Lautz, Lederer, Lewis, MacDonald, McGonigale, Maury, Monfort, Norbury, Orvis, Page, Park, Parkin, Parr, Prettyman, Reid, Ruthrauff, Savage, Sinsabaugh, Smith O. T., Spaulding, Stromquist, Symons, Talbot, Thomas, Trow.

ASSOCIATES.

L. M. Booth Co., by L. M. Booth; H. W. Clark Co., by Dwight P. Child; Glauber Brass Mfg. Co., by A. I. Fischer and L. Friedman; Glencoe Lime and Cement Co., by Wallace M. Smith; United States Cast Iron Pipe and Foundry Co., by T. N. Johnson; Hersey Mfg. Co., by J. J. Strasser; Hill Pump Valve Co., by Mark Wade; Irving, George; Marblehead Lime Co., by T. P. Black; H. Mueller Mfg. Co., by W. L. Jett; National Meter Co., by F. J. Bradley; Neptune Meter Co., by W. A. Start; Pittsburgh Meter Co., by F. H. Bradford and J. H. Davis; H. R. Worthington Co., by Allan W. Knapp; Dow Chemical Co., made an exhibit.

GUESTS.

W. O. Collins, Chemist Gulick-Henderson Co., Chicago; William A. Connolly, Chief Bookkeeper, Danville Water Co.; J. R. Davies, Evanston, Ill.; C. E. Ford, Department of Health, Cleveland, Ohio; W. D. Gerber, Consulting Engineer, Chicago; H. P. Harpstrite, Maroa;

G. B. Hills, Rivers and Lakes Commission, Chicago; William P. Holaday, Member of the Legislature, Danville; H. L. Hurst, Beech Grove, Indiana; F. C. Jordan, Secy. Indianapolis Water Co., Indianapolis, Indiana; John M. Keefer, Mayor, Macomb; David Kinley, Director School of Commerce, Urbana; W. H. Luckett, with Thomson Meter Co., Indianapolis, Indiana; Dr. A. J. McLaughlin, Surgeon, U. S. Public Health and Marine Hospital Service, Washington, D. C.; Oscar H. Olson, Law Dept. Sanitary District, Chicago; C. R. Richards, Professor of Mechanical Engineering, Urbana; T. T. Shoemaker, Mayor, Charleston, Ill.; W. E. Taylor, Chief Engineer, Water Company, Terre Haute, Indiana; H. C. Weinrich, Mayor, Cambridge, Ill.; R. M. West, Public Service Co. of Northern Illinois, Oak Park, Ill.; E. V. Wintzingerode, Chemist, Chicago, Ill.; J. M. White, Charleston, Ill.

PRESIDENT'S ADDRESS

OWEN T. SMITH.*

As president of this Association I feel that I have been the greatest kind of a failure. My own work has been so exacting that I have been compelled to slight the work of the Association. Yet, something has been accomplished and our most efficient Secretary-Treasurer has borne the burden of the work. There is this to say, the Association in the past year has justified its existence, in that it has helped to bring about the passage of the bill enlarging the scope of the State Water Survey, and has brought various communities in the state to a better knoweledge of themselves and by so doing has helped them to help themselves. It is very gratifying too that the bill passed the House with only three votes against it and had a large majority in the Senate.

I have not been informed how many places have received advice concerning their water supply or how many lives may have been saved by the activities of the Survey, but this one thing is sure, the Legislature appropriated no money which ultimately will be productive of more good than that appropriated for the use of the State Water Survey.

Prof. Bartow in his paper will tell us of some of the things accomplished.

The Presidential address of last year from our last president shows a most thorough grasp of the aims of this Association. It shows the good we all might do if we were ready to press into the collar and not "fly back" when called to pull strong and steady toward the end in view. Attention is attracted to one paragraph toward the end of his address reading like this: "And this only can be done by knowing how to give good service all the time, how to make a good deal with your City Councils and your large consumers, how to get and retain the friendship of the public and your employes, how to increase your business and hold it, how to get all the returns the traffic will stand, how to get all you can and save all you get." If that description of a

*Supt. Freeport Water Co.

man doesn't concentrate in one personality, Rockefeller, Carnegie, Maury, Slocum and Bartow and put everybody out of the running I have missed my guess. All this, for the compensation of a clerk, is exactly what a board of commissioners or a board of directors expect. There is one more sentence which I would like to add: "Don't insist too much on your own importance. You may be *it*, but forget it once in a while."

We have heard wonderful accounts of the meeting of the Indiana Association and it has fired me with an ambition to make the Illinois Association a much greater institution than it is at present. However as our duty is to be useful not according to our desires but according to our powers we can make this association just what we will, if we have a backbone and not a wishbone. This is how, "Sedulously attend, pointedly ask, calmly speak, coolly answer and cease when we have no more to say."

Our opportunity is now, and I am afraid it has been with me like this from anonymous, "Did it ever occur to you that lots of people don't know any better than to take trouble by the forelock and opportunity by the tail." We cannot solve every problem; men of the past did not, the men of the present have not, yet our aim should be to solve as many of them as possible. We need have no fear but some problems will be left for our children to solve, however ambitious and efficient we may be. It was Bismarck who said, "Let us leave our children a problem or two; they might find the world very tiresome if there were nothing left for them to do."

This Association was born and reared for service, real service to the water works fraternity and the people they serve. Any one contributing even a little toward that end is in service, and there is not one member but can help a little by telling his experience in overcoming a difficulty of repairs, of construction, or administration.

Before closing this address, the question of the place of meeting should have attention. It has come to me from several sources during the year that a number of men, especially of men in charge of municipal plants, would like to change the custom of meeting here. They say the meeting is something of a holiday with them and they would like a bit more entertainment which would be afforded by having the meetings in different places. There is some force in the argument and yet there are numerous reasons why it is better to come here. The matter should be discussed thoroughly and an endeavor made to obtain the best thing for the Association, which is trying to best serve members and gain the greatest good for the greatest number. W the best thing is found, do it.

Let me close with this
Reflection of the active member.

Convention day is now at hand,
Association makes demand;
Every member on the job,
Though by preference facing mob
When in thought, with dread, he sees
His paper read with trembling knees,
While discussion perforates
Every theory which he states
He has proved beyond a doubt.
Yet, Oh, members keen and sure,
In convention, publish cure
For our troubles great and small,
And we'll thank you, one and all.

A CITY SOURCE OF SUPPLY. AND DOES THE WATER METER INCREASE REVENUE, REDUCE CONSUMPTION AND SATISFY THE CUSTOMER?

BY R. R. PARKIN.*

The Source and Quantity of a Supply. This question lies at the very threshold of a system of water works, and it is of such paramount importance that to it the other features of the system must be accommodated. In fact, upon its proper solution the success or failure of the works depends. The river water taken out at any point answers for fire protection; but the water to be supplied to the people of a city for their daily use should be as abundant, as pure and soft as the circumstances of the location of a city admit. The water supply is an important factor in the health and well-being of a community, and mistakes in the selection of a source have been the cause of serious epidemics and failures.

From a business standpoint, it is plain that if a city expects to sell water to its citizens and to sell as much water as possible and have it judiciously measured, in order to make the works self-sustaining and ultimately productive of revenue, it must have such water as the people want to buy, that is—such water as is suitable for all domestic and manufacturing uses.

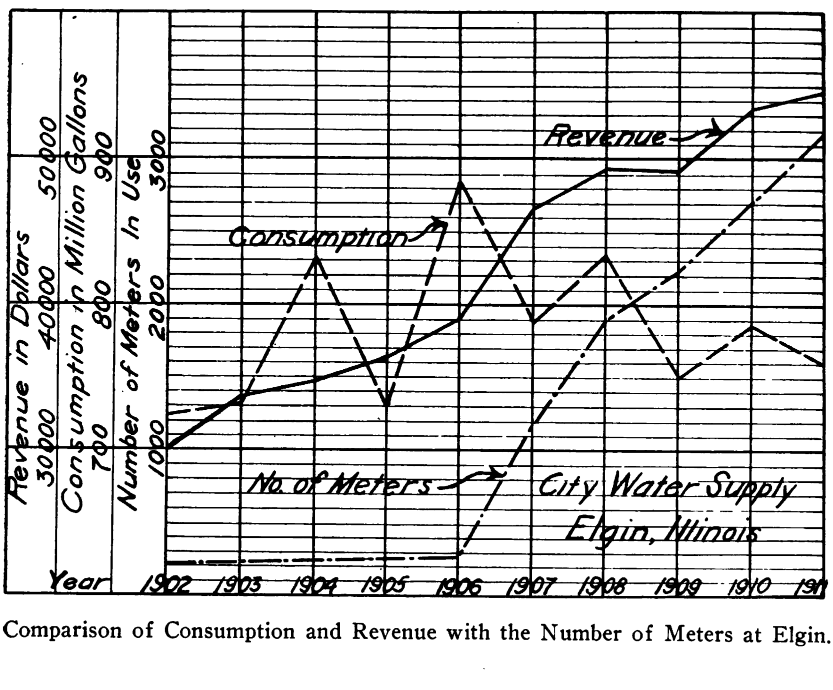
In dealing with this question in our city, atttention was called to numerous springs which come to the surface in and about the city. These singly and combined showed their inadequacy. This fact turned the attention of the Board to the river. After analysis made by Professor Kedzie of the Michigan Agricultural college, as the river water showed absence of chlorine in appreciable quantities, absence of free ammonia and a low amount of albuminoid ammonia, indicating freedom from sewage contamination, the river was adopted as the source of supply.

Filtered river water was furnished to our patrons for eighteen

*Chief Engineer Water Department, Elgin.

years, with good results; and during this period we had authority, which we enforced by law, for preventing the pollution of the stream above us. But since our Supreme Court has passed upon the drainage act for our great city, we, with all other cities, are without power, once enjoyed, to protect our once fair water supplies.

About six years ago we installed four large wells and connected them by what is known as the shaft and tunnel system. From this system we soon found that to meet the demand of our growing city we either had to install more wells to meet these demands or mix the artesian and river water. We were for a time compelled to do this against the wishes of many, allowing our people to use all the water they wanted, as before, upon what is known as the "Unfair" or "Flat" rate. During this time we commenced to consider the advisability of installing more wells, and of various other methods of getting away from using river water entirely. More wells, and the best location of same was carefully gone over, and finally, after considering all propositions we took up the meter question. The expense of going after more water was considered, also the cost of metering all consumers was taken into consideration. Finally a Meter Ordinance was presented and passed, and meters are being installed, about 500 to 600 each year. In addition all new consumers are metered as connections are made.



Comparison of Consumption and Revenue with the Number of Meters at Elgin.

As the time of this paper is limited I will give you the results up to December 31st, 1911. In 1902 we had 3263 consumers; of these 210 were on meters. The water pumped was 725 million gallons from which we received $30,013.68; for the month of December the daily average was 1,884,124 gallons. The income per tap for the year $9.20.

In 1903 we had 3463 taps of which 222 were metered. We pumped 730 million gallons of water and received for same $33,308.39, the average per tap being $9.62. The pumpage increased for December to 2,311,809 gallons per day, being 427,685 gallons per day over the same month in the year 1902. The average income per tap was $9.62.

In 1904 with 3643 taps, 240 were on meters. We pumped 833 million gallons of water for which we received $34,620.25. The daily average for December being 2,441,683 gallons, showing a daily increase of 129,874 gallons over 1903. With an average per tap of $9.20.

In 1905 with 3795 taps and 264 of them metered, we pumped 730 million gallons of water for which we received $36,200.47. For December the daily average was 1,670,761 gallons, a decrease of 770,922 gallons per day. The average income per tap was $9.54.

In 1906 with 3923 taps of which 286 were metered our consumption ran up to 888 million gallons. For this water we received $39,022.33, and for December the daily average was 2,072,655 gallons, showing an increase of 401,914 per day for December over the corresponding month in 1905. While our revenue was increased by $2,821.86 over 1905 the cost in operating expenses increased $2,713.93, showing the gain of only $107.93 for the year. In 1906 came the turning point, more water pumped and operating expenses increased; both of which reached the highest limit in our experience. The revenue per tap was $9.94 for the year.

In 1907. I wish you to note the beginning of meter installation proper, also receipts and consumption. With 4030 taps or consumers and 1170 of these metered by city and private consumers, our pumpage was reduced over one hundred million gallons, and the revenue was $7,723.73 over that of 1906 with a revenue per tap of $11.60 as compared with $9.94 for 1906. The pumpage for December averaged 1,980,683 gallons per day. The meters installed during this year were upon all business blocks, also in all public services including public cemetery, school houses, fire stations, drinking fountains, public parks, street sprinkling carts—none escaped. All public uses are metered in our city.

In 1908, with 4195 consumers we pumped 835 million gallons of water. We received $49,159.66. These figures you will see compare quite closely with those of water pumped and receipts, showing an

increase of twelve cents per tap over 1907. The daily consumption for December was 1,869,505 gallons.

In 1909, with 4420 consumers of which 2223, or 50%, were metered, we pumped 749 million gallons of water against 835 million gallons in 1908, for which we received $49,159.34. The average per tap being $11.12. Our meter rates were reduced on the residence consumers from $6.00 to $5.00 minimum which went into effect in 1908. Also general rates in some classes were placed on the downward scale which reduced our receipts somewhat. The daily average consumption for December was 1,931,007 gallons.

In 1910, with 4655 consumers and 2728 metered, we pumped 787 million gallons of water. The receipts from same were $53,687.63, a gain of $4,527.97 over 1909. The average per tap being $11.53. The daily average for December being 1,540,915 gallons and 390,092 gallons less than for the same month in 1909.

In 1911 with 4845 consumers and 3200 on meters, we pumped 759 million gallons of water, which is only 34 million gallons in excess of that pumped in 1902 for 3263 consumers, and a net revenue for 1911 of $54,853.06 showing a net increase for 1911 over that of 1902 of $24,839.38; the water pumped being about the same in both years. The average water per day during the months of December in each year was per tap. The average in 1902 was 577 and in 1911, 299 gallons or 278 gallons per day in favor of the meter and a net gain of 232 per consumer for the same period. Our average for December was only 1,403,477 gallons per day, the smallest amount for this month since the year 1900.

In conclusion I wish to say that we believe the meters installed have more than fulfilled our most sanguine expectations and are no longer a matter of experiment with us. Had we continued with the "Unfair" rate up to this time we would have expended many times the amount we have paid for meters in filters, settling basins, new machinery and buildings.

Our water users are more than satisfied with the service. Very few have been compelled to install meters and then only where the department found violations in the use of water. The city furnished all meters, except those using in excess of 10,000 cubic feet per quarter. The consumers pay for the installation only. They are read in three divisions every three months by one man. This work does not occupy his entire time. For valid reasons consumers can have their meter read each month.

By the use of meters water users soon find that to waste water is unprofitable. The livery and garage keepers shut off the water after washing vehicles instead of throwing their hose upon the floor

to run for hours, in most cases without a nozzle; automatic sprinklers are no longer allowed to remain for hours stationary for cooling or ornamental purposes; repairs are more quickly made after the user finds his bill has doubled. In most instances the user acknowledges the leak having had little knowledge of the amount of water wasting through so small an aperture. In fact your inspection is reduced to a science by the meter which relieves the department of many unpleasant duties in inspecting private premises, which is more pleasing to the lady of the household.

By this system, you can reduce your operating expenses, husband your supply. A saving in equipment, with more satisfaction to both seller and purchaser, should be gratifying to the operator, whether private or public owner; for you can greatly increase your revenue without the least injustice to your consumers.

Whoever he be, rich or poor, pays only for that which he uses, be it judiciously or wastefully, and upon equal measurement with his neighbors.

EFFECT OF INSTALLING METERS AT DECATUR.

BY HARRY RUTHRAUFF.*

As to the effect of installing water meters at Decatur, Illinois.—First let me say I do not wish to claim the title of an expert; but simply wish to state the facts as I have found them during my twenty-two years experience in the water department at Decatur.

I believe it important for every community to obtain and conserve, without unnecessary waste, a water supply ample and suitable for all purposes. The question with me from the beginning of my experience was,—"How to Stop Unnecessary Waste?"

I was first employed as a laborer in this department; later as foreman and finally in the year 1894 was appointed water inspector. I therefore knew of the great waste of water upon entering the duties of my office.

The first five years I served as water inspector I worked faithfully in an effort to stop the waste, which was enormous, due to carelessness on the part of consumers and defective plumbing. I used every honorable means along this line, always looking after this work personally. In 1896 I employed four assistants with the avowed intention of stopping all leaks, and thereby preventing waste in the city. I again went over the city in 1898 with four assistants, looking after this waste, giving the matter personal attention.

I brought into our police courts citizens by the score and prosecuted them for willful waste. After about five years labor along this line, I began to get discouraged. I found that a great many of our citizens believed we had an inexhaustible supply of water, therefore could not see any good reason why I should be so extremely anxious about this matter. Consequently, I began to look for some other plan. I believed, if this waste was allowed to continue, taking into consideration our rapid increase in population, we would in a short time find our supply short, or be at an unnecessary expense for additional machinery, mains and enlargement of our reservoir and filter plant to handle water merely to be wasted.

*Commissioner of Public Property, Decatur.

In 1901 I recommended to the council the adoption of the water meter on all services. The recommendation was filed, but no action taken. Again in 1902 I urgently recommended the same plan and was then ordered to have all livery stables, hotels and laundries install meters. I was then able, by comparison, to prove the water meter would be beneficial both to the city and the consumer, and each year thereafter I strongly recommended the placing of all meters on all services, and finally in the spring of 1908, the council ordered all services metered by July 1st, 1908. The results are as follows:

April 31st, 1904, the end of our fiscal year, we had 2112 services recorded; five consumers for each service gave us 10560 consumers; 987 of these services were metered. I wish to say here that there was no record kept of the water pumped prior to the year 1903. However, with 10560 consumers, 4,935 of them metered, there was pumped for this year 1,023,463,180 gallons, which gave us a per capita consumption of 266 gallons.

Revenue for this year was..........................		$ 32,812.99
The operating expenses at plant for this year were....	17,100.84	
The operating expenses, outside of plant, such as laying mains, repairs, etc., were..........................	5,899.16	
The total expense		$ 23,000.00
Leaving a balance of		$ 9,812.99

The plant was operated at this time with two shifts with coal costing $1.50 per ton.

For the fiscal year ending April 31st, 1911, we had 4939 services in use, 4933 being metered. I will say the 6 services unmetered are large consumers. This gives us, on a basis of 5 consumers to the service, 24,695 consumers. There was pumped during this year 1,124,212,338 gallons, which is 100,749,158 gallons in excess of that for the year ending April 31st, 1904. With an addition of 14,135 consumers, we now have a per capita consumption of less than 125 gallons. It is my belief that if the six consumers previously mentioned were metered, our per capita consumption would be less than 100 gallons. This may yet seem excessive to some, but we have some very large consumers for a city of our size, having 6 consumers using annually about 300,000,000 gallons.

The operating expenses at the plant for the year ending April 31st, 1911, were	$ 30,657.23
The operating expenses outside of plant, laying mains and miscellaneous were	26,960.01
Making the total expense	$ 57,617.24
The revenues for this period were	52,577.00
Leaving a deficiency of	$ 5,040.24

We now have three shifts at the pumping station, with coal costing us $2.15 per ton. The lowering of the water rates a few years ago and increased cost of operation are the causes of the deficiency, which has been overcome by a slight raise in water rates effective July last.

We have accomplished by the enforced use of meters at least a 30 per cent reduction in the average house-holder's bill. Under the old flat rate system a 7 room modern house would cost him $17.00 per year and under our present system, his yearly bill should not exceed $12.00.

We have also cut the per capita consumption from 265 gallons to 125 gallons,—thereby saving, at the present time, an unnecessary pumpage of 1,270,928,175 gallons each year. Therefore, the benefit derived from a complete metering of any city is very clear to me.

DISCUSSION.

Maury: I would just like to add a little word of caution at this point. The authors of these interesting papers have shown some results that can be accomplished by the introduction of meters. That step is in line with all modern practice. No one can deny that meters, when properly treated, result in benefit to the water department as well as to the consumer. At the same time the fact should not be forgotten that the meter operates solely through the pocketbook of the consumer. It imposes a constant and vigilant inspection that is impossible of attainment in any other way. But if meters be installed without a careful regard for the proper return, a great deal of money may actually be lost through their use, and the meter may at the same time lose much of its efficiency as a means of checking waste. I know one plant which, without due study of the rate conditions, metered 50 per cent of its services in one year, and cut down its revenue 33⅓%, almost bankrupting itself. There is another city in which the installation of meters accomplished less than 60 per cent of the reduction in waste which would have followed had the rates been properly adjusted, while at the same time the annual net earnings were reduced

by more than three hundred thousand dollars. Many other instances could be cited to show that in order to develop the efficiency of the meter without loss to the department or to the consumer, it is necessary to adjust the rates with the greatest care. To set meters blindfold, without regard to rates, is to court disaster.

Allen: I would like to ask several questions. Was there any revenue for free water included in those receipts? Was there any allowance for fire protection or any free water along that line that would be a drain on water on the revenue touching those points.

Parkin: In Elgin we received nothing from our hydrants until 1908, when meters began to be installed. According to an ordinance we received from that date $10.00 apiece. When we commenced metering we commenced with that line of consumers, public schools, public buildings and parks. Parks are owned by the city. An electric fountain taxed the pumping station and we told them they used more than $1000 worth of water. After meters were put in they paid us $375.00 the first quarter. They have not run it much since.

Allen: The water department is continually extending its lines to keep pace with the increased demands for water. Unless checked the public is very wasteful yet blames the water department if an attempt is made to check unlimited use of water. Such waste affects the department by causing an excessive use of coal, the pumps become too small, the boilers will not generate enough steam and more money is demanded in all divisions of the department. The engineer is blamed because of the increased expense, whereas the real cause is in the excessive use by the people. The public feels that it will be obliged to forego conveniences if the meter is put in and therefore the meter is a public horror. The people think water should be free. In addition to this the water department must often furnish water for fire protection, sewer and hydrant flushing, etc., and if it receives no revenue from these demands I estimate it will furnish one gallon for revenue and three gallons for waste. Such a waste should certainly be checked.

Parkin: One thing. I have always wanted to put in meters on each tap. The conditions of our finances did not allow it and year after year we put in a few. When we commenced metering our city it was not a question of revenue as much as supply. The question was, if we put on a meter we can husband our water supply. We were pumping four million gallons per day, when in one of our neighboring cities, they were only pumping two. They had a meter on each tap. With this example in another city, the Board finally decided to get an ordinance through if they could. It went through. We expected at

the time that our revenue would tumble down some but that we would reduce operating expenses. We are today paying less for operating expenses than in 1903 and pumping less water and our revenue is more than one-third more and we were gratified to know that the increase was from meters.

MacDonald: The meter will reduce the consumption of water. At the same time I am heartily in accord with the remarks of Mr. Maury, because thought concerning the reduction in revenue is necessary, so that the meter proposition may be a paying one in every respect.

I was particularly pleased to hear the paper by Mr. Ruthrauff of Decatur, for the reason that I have been somewhat puzzled in the past when people who had formerly lived in Decatur and had moved to Lincoln, began immediately to have a row with us over the water rates, especially meter rates, and they told me of the low rates they received in Decatur. I could not understand it. But from Mr. Ruthrauff's paper it seems that the revenue received in Decatur is hardly sufficient to pay operating expenses, and no fixed charges are taken care of by the income from water rates. I do not believe that my directors would stand for anything like that. We try to secure enough revenue from our meters to make it pay.

Irving: There is no doubt that the use of meters places the sale of water on a business basis. I think we all admit that and when we listen to a man who, starting in as a laborer, has been placed at the head of the Public Works Department as commissioner, and Mr. Parkin who has had over 20 years experience, tells these facts we cannot do anything else but take notice. Water is a commodity and should be sold by weight or measurement. The people should pay for what they use. I do not forget the point that Mr. Maury and Mr. MacDonald have brought out, that there should in all cases be a reasonable meter rate, and the question arises what constitutes the reasonable meter rate. I think the cost of production and the delivery of the commodity should be considered. What might be a reasonable rate in one city would be very unreasonable in another. For instance, we do not expect Mr. Henderson to take the water out of the river, handle it twice, filter it very carefully and distribute it to the consumer, for the same price that a municipality or any other company might take raw water and with one handling distribute it. Meter rates to my mind must be made in accordance with the cost of producing the water supply. In view of the facts expressed in these two papers, I see no reason why water cannot be handled as other commodities are handled and that the consumer should be willing to pay a reasonable price.

Trow: We go over our meters to read them twelve to fifteen days before the bills are sent out. During this reading and inspection, if we find any leakage we report it at once to the consumer. In this way we forestall the returning of the bill and the usual complaints which come with it and place the consumer in a position to have the leaks repaired at the earliest possible date.

We started in testing all meters free of charge upon complaint of the consumer, but soon found there were not enough days in the week to test meters. Under our present arrangements we gladly test any meter upon request of the consumer and all charges which arise from so doing are charged to the consumer unless the meter is found to register fast.

Ruthrauff: In regard to the efficiency of our plant. Mr. Maury spoke with regard to a fixed rate in regard to meters. We have changed our rates twice since adopting the meter system. When operating under the meter system, our plan was to stop waste and then get an adequate return, and our adequate return for four years shows a deficiency of $5000. But since the rates were made some four or five years ago our cost in operation has increased, and some two years ago when we had what we called dry times, the old council lowered rates again in order to cut down revenue. Last July we raised the minimum rate 50c and we expected 50c minimum rate to overcome the deficiency. Our rates remain the same, 8c down to 4c, with a minimum rate of $1.00 per quarter.

Amsbary: I think that we who have had considerable experience will agree that the meter is the real solution of our troubles with water supply and revenue and things of that sort, but I know there are cases where water works superintendents and managers who have had little experience with meters are somewhat doubtful on this subject. For instance, I received a letter from a superintendent of a plant in Kansas, who heard I favored the meter proposition and wanted to know why. The little experience he had had been unfavorable. It was the means of cutting down his revenue very fast and was not decreasing his pumping. That was contrary to my experience, so I had to stop and think. I asked him how many meters he had, whether it was optional with the consumer or whether the company ordered the meters in. He replied that he had about 2000 consumers and about 50 meters, and had put meters in on the request of the consumer, and so I wrote to him that naturally the one who wanted the meter was the economical consumer. All water plants have a pretty high flat rate, usually $5.00 a year for water closets, same for a bath, domestic use, $6.00 to $8.00; sprinkling and stable use added, making the ordinary rate for residence consumers $26 to $30 a year, while the meter rates run from 50c to

25c per thousand gallons, and by placing meters they could get their bills down to $8.00 to $10.00 a year and have all the water they wanted. I explained to him that if the Water Company would select the wasteful consumers and put meters on them, he would find the results different. I do believe that any plant would give favorable results if meters were introduced on every service.

Smith: If the rate is so low that several thousand gallons of water may be used per month for a nominal sum, meters will not save your water supply. For instance, suppose a consumer may use 10,000 gallons per month for fifty cents, which may be three times what he actually needs, he will not be much interested in cutting down the use of water.

DeBerard: I do not understand some of the figures of Mr. Parkin. In 1902 he has $9.20 revenue for each service and in 1911, $11.53, an increase of about $2.30 to each service. Increased rather than lowered.

Parkin: These are the results, much to our surprise, for where meters are installed we get pay for all water that the meter indicates, whether used, or from leakage. If from leakage, the consumer is informed by the meter reader, when the leak is detected. We have a card, on one side of which is the rate; on the other is figured out from 100 cubic feet up to 27,100 cubic feet the charge per 100 cubic feet. We give a discount of 5%. By this card the consumer can figure the amount he is to pay. Most all notices are delivered. This is a saving of postage.

THE NEW WORK OF THE STATE WATER SURVEY.

BY EDWARD BARTOW.*

The year 1911 marks a notable advance in the work of the State Water Survey. The 47th General Assembly passed a bill "imposing new and additional duties on the State Water Survey" and made an appropriation to carry out the provisions of the bill. The substance of the bill is as follows:

Section 1. Be it enacted by the People of the State of Illinois, represented in the General Assembly: That the State Water Survey, heretofore established at the University of Illinois, shall in addition to the duties heretofore imposed upon it, be authorized and instructed to employ such field men as may be necessary to visit municipal water supplies and inspect water sheds to make such field studies and to collect such samples as are necessary, to analyze and test samples and to make any investigations to the end that a pure and adequate public water supply for domestic and manufacturing purposes may be maintained in each municipality, to make sanitary analysis free of charge of samples of water from municipal water supplies or from private wells collected according to the directions of the State Water Survey, and to report the result of such examination to the Board of Health, Superintendent of Water Works, other officer or officers of the Water Department of the city, village or incorporated town or to citizens by whom the samples, respectively, were collected.

Sec. 2. That the sum of fifteen thousand dollars ($15,000) per annum, or so much thereof as may be necessary, is hereby appropriated out of any money in the State treasury not otherwise appropriated, to be used for the payment of salaries or other compensation of the assistants and employes and for such other expenses as may be necessary for visiting municipal water supplies, inspecting water sheds, making field studies, and collecting and testing samples of water, and for making any investigations that will show how to best obtain or conserve an adequate supply of pure water for domestic and manufacturing purposes in every section of the State.

*Director Illinois State Water Survey.

Sec. 3. That an annual report of the work of the State Water Survey and such special reports as may be necessary shall be published.

Without the aid of the members of this Association, and of its Committee on Legislation, consisting of Mr. F. C. Amsbary, Mr. H. B. Morgan, and Mr. W. J. Spaulding, the bill could not have passed. It, therefore, seems appropriate to inform the Association of the progress which has been made.

The Water Survey has been carrying on a scientific study of water conditions in the State for 15 years, and this study has shown the need of funds for the employment of field men to visit all parts of the State.

What might be called a field or engineering division of the State Water Survey has been organized with the following staff:

Engineer, Mr. Paul Hansen, a graduate of the Massachusetts Institute of Technology, 1903; Engineering Assistant with the Massachusetts State Board of Health, 1902-3-4; Engineer with the Pittsburg Filter Company, 1905; Assistant Engineer, Ohio State Board of Health, 1906; Acting Chief Engineer, Ohio State Board of Health, 1909; State Sanitary Engineer of Kentucky, 1910.

Assistant Engineer, Mr. Ralph Hilscher, a graduate of Beloit College, 1908; Massachusetts Institute of Technology, 1909-10; Assistant Engineer, Massachusetts State Board of Health, 1910.

Assistant Engineer, Mr. Walter G. Stromquist, a graduate of Bethany College, Lindsborg, Kansas, 1905; University of Kansas, 1906; University of Illinois, B.S., 1910; Assistant Engineer, Excelsior Springs, Missouri, 1910.

Inspector, Mr. W. F. Langelier, a graduate of New Hampshire College, 1909; Chemist State Water Survey, 1910-11.

The laboratory staff is practically the same as before, excepting the addition of another chemist.

It is not the purpose of the Engineering Division of the State Water Survey to do the work ordinarily done by municipal engineers or by consulting engineers. We are not going to do engineering work, but to see that water companies and municipalities proceed along proper lines in making additions or in the construction of new work.

To indicate the character of the work that may be done, I need but say that there are 115 municipalities of 1000 inhabitants or more without general water supplies. Our investigation has shown that in that part of the State where the greater proportion of the towns are without water supplies, the typhoid fever rate is the greater, whereas in that section of the State where most of the towns have general supplies, the typhoid fever rate is lower. We have already had requests for assistance from several towns which are contemplating the installa-

tion of supplies, or the improvement of existing supplies; Anna Benton, Breese, Carlyle, Casey, Chester, DeKalb, Eldorado, Fairfield, Georgetown, Harrisburg, Mounds, Peoria Heights, and Rankin.

As shown in a report prepared for the Illinois Society of Engineers and Surveyors, the majority of the water supplies which obtain water from streams are furnishing an unfiltered water. In many cases the claim is made that the water is not used for drinking purposes. This situation may be criticised, because it is difficult to prevent people from drinking an easily obtained impure water. If the general supply is admittedly bad the residents will use water from shallow wells which may be worse. Several towns are considering the installation of filter plants, some of which we have been able to assist, namely: Mt. Carmel, Effingham, Pana, and Harrisburg.

We are also taking up again the regular control of the water furnished by filter plants already installed and are urging the installation of small laboratories for chemical and bacteriological control. Such laboratories have been established at Kankakee, Rock Island, Streator, Pontiac and Danville. The authorities at Alton, Elgin and Lake Forest are considering the installation of such laboratories. It is sometimes possible to make arrangements with local chemists to do the analytical work, as at Macomb, where the necessary tests are made by the Professor of Chemistry in the State Normal School, and at Evanston, where the work is done by a Professor of Chemistry in the Northwestern University.

Studies have been made of the water sheds of the Fox River and the Vermillion River, and of the shore of Lake Michigan from Chicago to the State line. These surveys have been made at the request of municipalities or citizens in the respective areas. In fact, the Survey prefers to do the work in response to requests from the citizens of a community, for then it is asured of local cooperation. The number and character of the requests which have come to us have been very gratifying, and the members of the Survey staff feel very hopeful for the future.

We propose to carry on what might be called a "Campaign of Education". We are prepared to give illustrated lectures to assist in influencing public opinion in favor of the introduction of general water supplies, the filtration of surface supplies, or in methods of sewage disposal.

We need the continued assistance of this Association. Tell us where work such as we can do should be done. Criticise us, and give us suggestions. If we have any data that can be of assistance to you, ask for it. If we have not the data needed, we will try to get it.

METHOD OF KEEPING TRACK OF EXAMINATION AND FLUSHING OF FIRE HYDRANTS.

BY DOW R. GWINN.*

There are some water works men who do not believe it necessary to flush hydrants, except on rare occasions, on account of the large amount of water necessary for this purpose. We believe that it is necessary to flush the hydrants at least twice a year; that in order to furnish satisfactory water at all times, the velocity in the mains should be increased occasionally in order to remove any loose incrustation or sediment. Therefore, in the spring and fall of each year, corresponding to the regular house cleaning periods, we arrange to flush and examine all public fire hydrants.

Ordinarily, it takes from six to eight men to do this work. Most of them are occupied in opening fire hydrants, while one or two follow with a wagonload of gravel, which is used to fill up any small holes that may be washed in the street. Each man is provided with a note book to keep a record of the condition of the fire hydrants. We endeavor to have from two to five fire hydrants open while the flushing is being done. Our hydrants have two 2½ inch openings, hence the velocity of water is very much greater than under ordinary conditions. During the flushing, the rate of pumping per 24 hours is increased very materially, the maximum increase being about nine million gallons per 24 hours. In order to control the streams from the fire hydrants and prevent undue washing of the streets, we use for each nozzle a standard hose coupling into which is screwed a 2½ inch nipple with a loose 45 degree elbow; this enables the men to change the direction of the stream by moving the 45 degree elbow.

Ordinarily, the men do not report to the office until the close of the day's work, but if a hydrant should be found in bad order; that is, in such condition that it could not be used by the Fire Department, the office is notified by telephone. As soon as this information is received, the Fire Department is notified at once and arrangements are made without delay for the necessary repairs.

*Manager Water Co., Terre Haute, Ind.

Our plan of flushing is to begin at the pumping station and work out on a line of pipe to the outskirts, then to come back to the starting point, or force main, and follow out another line to the end. By this method, the district disturbed by the flushers is not so great as it would be if done otherwise.

During the flushing and examination in October, 1911, there were eight men engaged in the work; an average of 160 fire hydrants were flushed per day; the total cost for labor and street car tickets was $113.00; the average cost per hydrant, a fraction over 11c; the approximate number of gallons used was 8,600,000, an average of 8,574 gallons per hydrant. The principal hydrants reported on by the men were as follows:

50 were hard to operate.
10 stuffing boxes leaked.
7 did not drain.
7 drip or waste valves were out of order.
1 needed new cap.
2 revolving nuts were badly worn.
1 was broken.

We keep duplicate hydrants, of the various sizes and patterns, in the shop and when a hydrant is reported out of order, we make substitution.

In addition to the regular flushings, we flush dead ends whenever it is necessary.

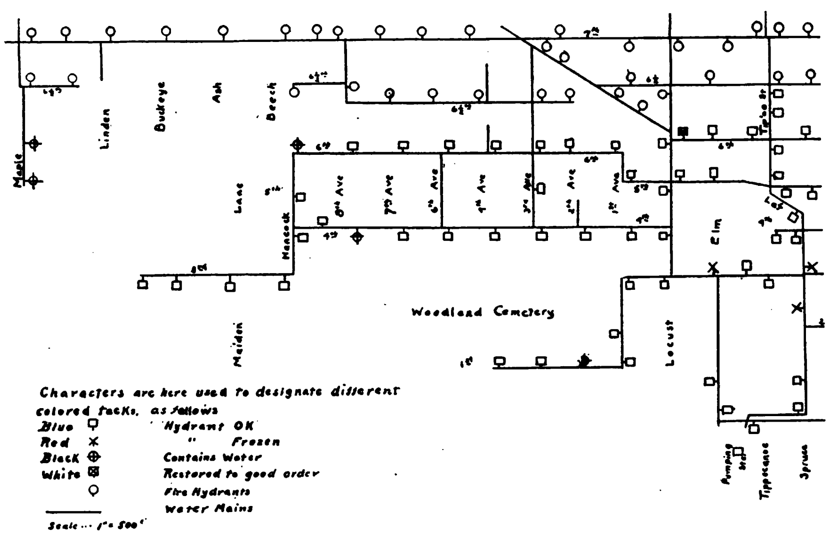
When hydrants are used by the Fire Department, one of our men makes an examination in order to determine if each hydrant has properly drained and has been left in good working order.

When the city needs water for flushing sewers, they notify us and we put on a 2½ inch controlling valve and open the hydrant. No charge is made either for the water or for the service. When the city is through with the use of the water, we close the hydrant and remove the controlling valve.

In addition to the examination of the fire hydrants at the time they are flushed, we make several examinations during the winter. We made examinations in November, December, January, and February in the past winter. This examination consists in dropping a weighted cord into the hydrant to determine if there is either water or ice in it.

We have lately adopted a new plan of keepng a record of the examination or flushing of the fire hydrants. We have blue prints of our mains showing all the fire hydrants. When the men report on the condition of the hydrants, tacks with colored heads are used to designate the condition of each (see map). For instance, if a hydrant

is reported in good order, a blue headed tack is stuck into the blue print at the point where the hydrant is shown. If the hydrant contains water, a black headed tack is used. If a hydrant is frozen or out of order, a red headed tack is used. As soon as a fire hydrant is reported frozen or out of order, we notify the Fire Department at once and also advise the Chief when the hydrant is put in good condition. We keep in close touch with the Fire Department at all times. Out of 1058 hydrants examined in February, there were five that were frozen, or about ½ of 1%. As soon as a report was made showing water in any of the hydrants, a man was sent out at once with a pump to remove the water. During the last inspection, there were fourteen hydrants that contained from one foot to two feet of water. As soon as one of



the frozen hydrants was in good working order and the Fire Department notified to that effect, the red tack was taken out and a white one substituted, showing that while the hydrant had been a "sinner, it had repented and was back into the fold again". We are well pleased with the system.

Maury: When I came in I thought the tacks represented water borne diseases in Terre Haute. I thought the blue, typhoid and the red and yellow other water borne diseases. Was relieved to have an explanation. With regard to inspection of hydrants we have been carrying it on in Peoria for some time, very much along the line that Mr. Gwinn has told about, only we do it in conjunction with the fire

department. Some years ago it was found that the firemen, in their haste at fires, handled hydrants very badly. Quite often they would open the hydrant fully; and where the hydrant was equipped with nozzle valves they almost invariably broke the stems off all the nozzle valves except the first one to which they attached the hose. With a view to stopping that, and with a view to familiarizing firemen with use of hydrants we started inspections, spring and fall, and we also started a school of instruction for firemen in the use of hydrants. In these inspections, blanks similar to the one here shown are furnished, and each hydrant is tested jointly by an employee of the water company and by a fireman. The blanks are so prepared that all of the difficulties

Peoria Water Works Company

FIRE HYDRANT TEST

Date.................... Test No....................
Location of Hydrant....................................
Kind " " ....
Number and Size of Nozzles.............................
Condition of Top Nut...................................
" " Drip ....
" " Nozzle Valves ....
" " Valve ....
Is hydrant ready for use?..............................
Remarks: ....
....
....
....
....

....
City Inspector.

....
Co. Inspector.

that fire hydrants are heir to have to be investigated and reported upon. The blanks are turned in at the close of the day, signed by the water company inspector, and by the member of the fire department whom he had out on the inspection. It is our pracitce to send new firemen each day on these tours of inspection so that each member of the fire department may have a chance to become familiar with the hydrants and to learn how to use them. We have established a rule now that each captain shall, immediately after a fire, report by phone to the office, stating which hydrants have been used by his company. An inspector is sent out to inspect the hydrants used, and to repair them if repairs are necessary. This, in spite of all of our precautions, is still very frequently the case.

THE LIMITATION OF STREAM POLLUTION.

BY PAUL HANSEN.*

Recently the writer undertook to present certain broad general principles that should govern in determining the limitation of stream pollution. To secure an authoritative basis for these general principles, circular letters requesting answers to a series of questions regarding stream pollution were sent to a number of sanitary experts throughout the country. A detailed discussion of these replies together with conclusions of the author, were presented in a paper before the Illinois Society of Engineers and Surveyors on January 17, 1912. The purpose of the present paper is to give the conclusions arrived at in brief compass.

Among sanitarians in recent years there has been a distinct aversion to making general statements in regard to the limitation of stream pollution, which is due to the fact that it is impossible to lay down any complete set of rules which would govern all cases. There is, however, a distinct difference between rules and principles and it is highly profitable to discuss general principles, whereas a formulation of rules would be difficult or futile. A specific problem cannot be intelligently approached without certain general principles clearly in mind, while rules might serve only to confuse. It is a failure to discuss general principles more freely that has led to wide variations in opinion among sanitary authorities regarding the problem of limiting stream pollution and has left the popular mind utterly chaotic in this regard.

In view of the above the writer desires to state that sanitary authorities should formulate, in the light of the most advanced knowledge, certain general principles which should form the basis of problems relating to stream pollution. These principles should not be regarded as an inflexible creed, but rather as a working hypothesis to be changed from time to time as experience dictates.

A statement of principles upon which there is a fair concensus of

*Engineer Illinois State Water Survey.

opinion would not only enable sanitary authorities to come to a better understanding among themselves, but would add greatly to the education of the public at large concerning the conservation of our streams. Such education of the public is most necessary if rapid and systematic advances are to be made in maintaining our streams in clean condition. It is true that in connection with a question requiring so much technical knowledge all of the detailed considerations must be determined by experts. On the other hand the general questions must always be determined by the people. The ability of the people at large to decide for themselves matters of broad general policy forms the very basis upon which the government of the United States was conceived, and this fact must be recognized in connection with the conservation of our streams as well as in connection with any other broad policy. In short, it is quite absurd for the sanitary experts to maintain that here is a problem which only they are capable of thinking about, when, as a matter of fact, they can scarcely hope to have these problems presented to them for solution until there has been awakened an intelligent interest on the part of the public. The public has a perfect right to know at least how streams may be regarded as to their function and in a broad way what limitations they have a right to place upon their pollution.

FUNCTION OF STREAMS.

There is considerable misunderstanding regarding the functions of streams and since this lies at the base of further considerations, it must be dealt with first. One extreme view of the function of streams is that they are provided by nature for conveying water to the populations that live upon their banks to be used freely for all purposes for which water may be needed and that, therefore, no one has a right to defile streams by discharging into them impurities which may injure health, reduce the value of the water in the stream for any purpose or add to the discomfort of the water user at points lower down upon the stream. The other extreme view is that streams are our natural drainage courses and that they were provided by nature for carrying off all the wastes of human activity and that to deprive persons of the right to so use streams is an injustice. In point of fact both of these views contain elements of right, and yet both are wrong. The proper conception of a stream recognizes the dual function of watering the country through which it passes and of carrying off wastes.

Some pollution of streams is inevitable; for with increased density of population, increased cultivation of the soil and increased numbers of urban communities it is practically impossible to prevent the dis-

charge of all deleterious matter into streams. It is only reasonable to require that the grosser form of pollution be prevented. It, therefore, may be stated that no surface stream, unless the entire watershed is controlled for the express purpose, can be considered as fit for use as a domestic water supply without purification. Many of the smaller communities are in a position to derive their water supplies from wells, and where well water is unobjectionable because of mineral content and is beyond the danger of surface contamination, this forms the safest and best of all water supplies. Most large towns and a great many small towns must, however, derive their water supplies from surface streams. The question now arises: how much pollution may be permitted to enter a stream before the water thereof is polluted to a point beyond redemption by water purification methods. This is a question that taxes the greatest ingenuity of sanitary experts. It is always dependent upon the peculiar character of local conditions and the best and most economical solution can only be obtained after careful expert investigation.

Merely to indicate the wide range of conditions that are met in actual practice, we have on the one hand the water purification plant constructed for the purpose of purifying crude though rather weak sewage at the Chicago stock yards. It was claimed that the results obtained at this plant were satisfactory when judged by the safety of the water for human consumption. Even though it is possible to transform such a filthy liquid into drinking water, the esthetic sense of the community rebels and it is not probable that water once so highly polluted, even with purification, will ever be considered as acceptable water for public water supplies. At the other extreme is the community which derives its supply from a clear mountain stream, possibly having its source in large springs yielding a water of unquestioned purity. In such a case there would seem to be but trifling danger, and authorities might be tempted to omit purification of such a water. The disastrous results that may come from this omission is well illustrated by the experience in Plymouth, Pa., in 1885. In this case the source of water supply was a mountain stream such as above described, with but two houses upon the entire drainage basin. Nevertheless a single case of typhoid in one of these houses was responsible for 1104 cases and 114 deaths among the consumers of the water.

STREAMS FOR PLEASURE PURPOSES.

Of recent years growing importance is attached to the maintenance of our streams for pleasure purposes. Every summer there may be found scattered along the streams within a radius of 50 miles or

more of our large cities numerous camps. This form of summer vacation is a comparatively cheap and normally a healthful means of recreation. It ought to be regarded as one of the means of improving the health tone of our urban communities inasmuch as it is within the means of so great a number of people. It is a striking fact that these campers invariably seek the stream valleys, which illustrates the cravings of men for a combination of land and water in which nature presents her most picturesque, most alluring aspects. Streams are used for bathing, boating, fishing, washing, cooking and in some few cases for drinking purposes. There is no reason why the streams should not be used freely and without discomfort for all the purposes above suggested except for cooking and drinking. For reasons already explained no water course can be maintained in its original and pristine purity; and, for this reason, the public should be educated by health officials, and in any other way that comes handy, to understand that water from surface streams is not fit for domestic consumption. It might be suggested, however, that in many instances streams may be kept so clean, without unreasonable demands being made upon riparian owners using them as drainage courses, that it should be, after boiling, altogether unobjectionable to use the water for drinking. Where streams are used for recreation purposes a valuable adjunct to sewage treatment is the now well known and understood method of disinfection.

FISH AND SHELL FISH.

Many streams are valuable to the community on account of their fish life. It may be said in general that there is rarely necessity for so polluting a stream as to endanger fish life, though there are some circumstances where the continuance of certain liquid waste producing industries is of so great importance to the general welfare that fish life in certain streams must be sacrificed.

The maintenance of fish life does not necessarily imply an unpolluted stream. It is merely necessary that the alkalinity of the water be maintained and that the pollution be not so great as to absorb the dissolved oxygen in the water to an extent that will suffocate the fish. The fact is; a moderate degree of pollution favors fish life in that it favors the growth of microscopic aquatic life which is valuable fish food. Certain difficulties have been encountered in the contamination of fish by polluted water which causes the fish to decay rapidly and become unfit for human consumption. The danger of infection of human beings with specific disease through eating fish taken from polluted streams is almost negligible; for the reason that in this part

of the world at any rate, fish are not eaten raw. With shell fish, however, the case is quite different, because they are very frequently eaten raw. It has been a common practice along the coast to float oysters in shallow polluted waters which causes them to become bloated and appear fat. Such an oyster perhaps makes a more delectable morsel of food, but in it may be lurking the germs of typhoid fever or some other water borne disease. The problem of protecting the shell fish industry is a very complicated one and all its intricacies have not been worked out. Here again is where the services of experts are needed to study each zone of shell fish pollution in the light of diverse local conditions. As a concrete example of the efforts that are made to protect shell fish may be mentioned the case of the city of Baltimore, which at the expense of millions of dollars is purifying its sewage so as to convert it into a liquid which is not only clear and inoffensive but also practically sterile.

MANUFACTURING WASTES.

Many of our important industries, such as paper mills, woolen mills, dye works, starch factories, and tanneries, require large volumes of water to carry on their industrial operations and also produce large volumes of waste which are capable of undergoing offensive putrefaction. The discharge of these wastes into streams often causes unsightly, and malodorous conditions, yet, with the exception of tanneries, these waters do not menace the public health since they do not contain the specific infections of disease. (Tannery wastes may contain anthrax bacilli). In fact some of the processes are such that the wastes are quite inimicable to the existence of disease germs. In some cases it is practicable to treat the wastes so that offensive conditions in a stream may be in part or wholly relieved, but for certain industries such treatment of the wastes is prohibitively expensive. Enjoining industries against causing objectionable stream pollution may, and in some instances actually has, necessitated the shutting down of works. It is conceivable, in the case of large industries upon which are dependent a considerable population, that an order to cease stream pollution, which is virtually an order to shut down the works, might result in great hardship without adequate returns accrueing from the cleaner conditions of the stream. There may be instances, therefore, where a limited few of the streams of the country may legitimately be turned over to the manufacturing interests. Now that the stream pollution problem has become more acutely an issue and the disadvantages of filthy streams is better understood it would not seem wise to permit waste producing industries to be located upon any but very large

streams which have an ample volume to dilute the wastes to an inoffensive condition. That is to say the streams which are now clean should be maintained clean for the reason that we have an ample number of large streams which can effectually take care of wastes from waste producing industrial plants for an indefinite period in the future.

THE SMALL COMMUNITY AND THE SMALL STREAM.

One of the most troublesome class of problems encountered by state authorities having supervision over stream pollution is that of the small town on a small stream which desires to install a sewerage system. By small towns are meant those that have populations of 10,000 and under. For health reasons it is quite important that such towns be encouraged to install sewerage. Probably one of the greatest causes of the continued prevalence of typhoid fever and intestinal derangements in small communities and rural districts is the outdoor privy. Anything that will tend to the elimination of these foci for the spread of disease by insects and by other means should be strongly urged by all health authorities. On the other hand if the installation of a sewerage system must be accompanied by the installation of expensive sewage purification works the project is very often defeated. Again, supposing purification works to be installed it is, practically, extremely difficult to secure in small towns proper operation thereof unless they are constantly under supervision of some central supervisory authority with unusual mandatory powers and large appropriations.

It sometimes happens that purification works must be insisted upon despite the above difficulties in order to adequately protect some public water supply taken from a point on the stream below. In such a case, supervision of some central authority combined by constant threats of damage suits on the part of lower communities results in fairly successful operation of the sewage purification plant, especially if the latter is of a design that involves no serious operating difficulties. There is another condition under which installation of purification works must of necessity be demanded and one under which there is likely to be obtained reasonably successful operation, namely, when riparian owners below require a stream in a reasonably clean condition for certain industrial or farm purposes and are in a position to secure damages whenever the purification works are not being properly controlled.

There are a number of cases, however, in which the streams, small ones, sure to be grossly contaminated by the discharge of sewage into them, and yet they endanger no water supply and flow through vallies in which there are few or no habitations so that the pollution is not at all likely to give rise to complaint. A strict adherence to the principle of maintaining streams in a clean condition would dictate the installation of sewage purification works regardless of these facts; but to the writer, this appears to be one of those practical conditions which necessitate a deviation from broad general principles in that the requirement for sewage purification must be waived until such time as the interests of the public demand the reclamation of the stream's purity.

LEGAL CONTROL OVER STREAM POLLUTION.

The matter of limiting stream pollution can be adequately controlled only by some central authority for the reason that the problem is essentially one of an intercommunal nature. If left to individual communities, very little could be expected in the way of results. Communities are not likely to be altruistic enough to spend large sums of money for sewage purification works to protect neighbors on the stream below unless such altruism is induced by damage suits which render sewage purification the cheapest way out of the difficulty. But law suits are costly if long drawn out and the results are often unsatisfactory.

It is necessary to repeat that specific problems relating to stream pollution must for successful solution be placed in the hands of experts and it is, therefore, necessary or at least strongly advisable that every state have an expert commission. Among many there is a strong prejudice against commissions inasmuch as the multiplication of commissions is looked upon as a delegation of legislative and executive powers to others than direct representatives of the people. This need not necessarily be so, however, for a law may be framed requiring in general terms that streams must be maintained in an inoffensive condition and that they shall not be detrimental to health. This leaves to the commission not arbitrary powers, but the simple function of determining points of fact within limits prescribed by prior legislative enactment. That is to say, the commission will determine when a stream is in danger of being made offensive and when it is in danger of being made detrimental to health, and thereupon decide what, if any, purification of sewage is necessary, what, if any, purification of industrial wastes is necessary, whether water supplies may or may not be taken from streams and to what extent they must be purified. Such

a commission should be supplied with ample appropriations to enable it to obtain all necessary information for its guidance whether this consists in maintaining laboratories or in carrying on experimental and research work. As even the best of commissions may at times grow arbitrary or become unduly biased in its views there should always be made provision for ready appeal from the decisions of a commission to an independent special arbitration board of experts, and, of course, there must exist the inalienable right of appeal to the courts.

SUMMARY.

Summarizing in the briefest possible terms, it may be said that all surface streams must of necessity be polluted to an extent that renders them unsafe as domestic water supplies without purification. On the other hand the public is entitled to clean streams and special protection should be afforded to those streams which because of their beauty and accessibility from the cities constitute valuable recreation grounds for urban populations. When not a menace to health, certain exceptions may be permitted with respect to the maintenance of clean streams. Such exceptions, however, must always be regarded as special cases, necessitated by unusual local conditions. A limitation of stream pollution is most effectively and most equitably carried out when under the general supervision of some central expert authority operating under somewhat elastic general laws which represent in broad terms the will of the people.

THE STORAGE OF COAL.

BY S. W. PARR.*

With each recurring period for the adjustment of the wage scale in the mining of coal, the entire industrial world is thrown into a more or less serious state of apprehension because of the possibility of a shortage in the fuel supply. A spasmodic activity is at once set up in the matter of storing an amount sufficient to bridge over the possible cessation of shipments. This activity in the demand abnormally stimulates the market and prices advance. The community at large then becomes sensitive to the fact that it, too, must join in sharing the result of the unfortunate conditions. Then to add to the seriousness of the situation, most, if not all, of the coal stored begins heating in the pile and thousands of tons take fire and are lost. This is only one of many circumstances which might be cited as a reason why it would be exceedingly desirable to be able to store coal, at will, in large quantities.

Probably, in the aggregate, even more salutary results would come from the ability to store coal if prices in the summer time were arranged, as is done with the anthracite industry, to stimulate the market at a period when the mines would otherwise be comparatively idle. The unequal distribution of market activities produces a demoralizing effect upon the miners habits of living and furnishes a most serious problem for the operator; as it must in any business, with such heavy fixed charges for maintainance and up-keep of the property. The ventilation must continue, the pumps must be kept at work and steam pressure be maintained; whether the daily output for the market is one ton or one thousand.

But it is unnecessary to multiply arguments to prove the desirability of being able to put coal into storage. The vital question is, *can it be done?* It is the purpose of this paper to review the conditions which lead to the heating of coal in the pile and deduce the underlying principles which must be observed if successful storage is ever accom-

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plished. The carrying out of some of these principles may be impracticable on a commercial scale. Or let us rather say—they may *seem* to be impracticable for sooner or later a way will be found for doing this thing, upon which so much of the welfare of the community depends.

Studies of the properties of Illinois coals along lines which would bear upon the storage question have been carried on for some time by the University of Illinois Engineering Experiment Station and by the State Geological Survey. These studies have resulted in a number of bulletins wherein many of the fundamental facts on this topic have been clearly and definitely developed*.

A brief enumeration of the most pertinent will be first in order.

I. There is a very marked avidity for oxygen on the part of freshly mined coal. This is due to two causes. In the first place, there are certain compounds present in bituminous coal which have an especial avidity for oxygen. This element they lay hold of and incorporate into their chemical composition. Secondly, coal, especially in the fine or powdered form, has the ability to condense or occlude oxygen upon the exposed surface, and the larger the surface the more oxygen can thus be held. The chemical reaction involved under the first property results in the generation of a small amount of heat. The generation of heat promotes the chemical union with the oxygen condensed on the surface of the particles thereby generating more heat. The direct corrolary, therefore, of this first proposition is, that any increase in the pulverization or shattering of the coal mass, by so much increases the opportunity for starting the initial form of combustion.

II. Any extraneous source of heat which will result in a rise of temperature within the mass will promote or start oxidation activities. It is perhaps unnecessary to recall that coal is a poor conductor of heat and any heat generated within the pile has a poor chance for escape; and the larger or deeper the pile, the poorer the chance. Its presence, moreover, within the mass is exceedingly conducive toward the generation of more heat by setting in motion those chemical activities which are dormant and which only await a slight rise of temperature to begin their work. These extraneous sources of heat may be enumerated as

*University of Illinois Engineering Experiment Station Bulletins as follows:

Weathering of Coal—No. 38. By S. W. Parr & W. F. Wheeler.

Occluded Gases—No. 32. By S. W. Parr & Perry Barker.

Spontaneous Combustion—No. 46. By S. W. Parr & F. W. Kressman.

follows: steam pipes running under or near the pile; contact with a wall which is heated on the other side by reason of the proximity to a furnace or other source of heat; impact of coal due to unloading in certain spots, the accumulation of dust at such points adds to the danger; storing in hot weather or under conditions where the reflection of the sun's rays or other climatic conditions give an opportunity for the accumulation of heat along with the coal mass.

III. The presence of a high percentage of iron pyrites or sulphur rock. As shown in the experiments on Spontaneous Combustion * the oxidation of only 1/5 of the pyrites in a coal with 3% of sulphur will raise the temperature 70°F., assuming that no heat is lost by radiation. This is quite sufficient to start up the other oxidation activities referred to under division I.

IV. The presence of moisture is so pronounced an accelerator of the pyritic or sulphur oxidation that special mention of it is made under a separate division. By reference to the experiments above referred to in Bulletin No. 46 it will be seen that moisture plays a very important part in promoting the oxidation of sulphur present in the form of pyrite.

Having thus enumerated the fundamental principles underlying the promotion of spontaneous combustion, let us see what remedial measures might be employed for counteracting oxidation. Be it noted furthermore that we shall not be hampered in our discussions by the question of practicability; for what is impracticable to-day, by the versatility or resourcefulness of some man, or by the unforseen development in some related line, may become the practice of to-morrow.

First, is the matter of submergence or storage under water. There is more accomplished by this procedure than the mere protection from fire. Of course coal under water will not burn. But, note that conditions outlined under No. I are rendered inactive, so that oxidation and deterioration are prevented.

The storage of coal by submergence therefore meets all of the theoretical conditions for preventing both combustion and loss of heating value. Of course the expense of storage reservoirs is great but that it is not prohibitive is shown by the fact that quite a number of such reservoirs are now in use in this state. Indeed, this method may be said to have passed the experimental stage.

For storing coal in the air above ground one condition alone, if it could be secured, would accomplish the result. This condition is

*Parr & Kressman, University of Illinois Engineering Experiment Station, Bulletin No. 46. Page 52.

a cooling or refrigerating effect sufficient in amount and long enough continued to counteract the period of low oxidation already described.

Professor Lewes has recognized this fact in making his recommendation for coaling the vessels of the British navy that there be stored along with the coal, steel flasks of carbon dioxide compressed to liquid form. These flasks were to be 3" × 12" and to conatin 100 cubic feet of gas. They were to be supplied with fusible plugs which would melt at 200°F., thus liberating the gas and producing both an inert atmosphere incapable of supporting combustion and also a zone of intense cold. One such flask, he estimated, would take care of about 8 tons of coal. While this method could doubtless be used with success in the storage of coal on shipboard, it would be very difficult and expensive to carry out in the usual method of open piles. The method is of interest, however, as furnishing an illustration of the recognition of one condition, namely the counteracting or preventing of the initial rise of temperature. If ice were sufficiently cheap and abundant and accessible it could doubtless be distributed throughout the mass in the process of storing in a manner to accomplish the same result. A system of refrigeration pipes for circulating cold brine would be also effective; but would require a refrigeration plant and power to operate it. This would require too great an outlay for the occasional use.

Another of the fundamental conditions, which may furnish suggestions worth noting, is the matter of finely divided material. From the data acquired in the study of causes which led directly to spontaneous combustion,* it was demonstrated that the finely divided material, the duff or dust, was the condition most conducive to the initial reactions and the generation of heat. This activity decreased directly in proportion to the increase in the size of the particles.

Conversely, therefore, it would seem to be true that the storage of lump sizes, free from fine material would be a practicable proposition. In considering this phase of the matter, however, we are at once impressed with the necessity of beginning our storage process at the very beginning, that is at the mine and in the very process of working out the material from the vein. The present day method of blasting, with its excessive depth of hole and excessive charge of powder, yields the first and most fundamental difficulty in connection with safely storing the output of such practice. Here, indeed, the miner is his own worst enemy. The difficulty resides not alone in the pulverizing effect of the shot; but in the shattering or passing of the elastic limit of the entire mass; so that even though much of the ma-

*Bulletin no. 46.

terial retains a lump form, it is easily shown to be threaded through and through with a net work of fissures, which while not widely enough apart to cause a crumbling of the entire mass, is still sufficiently open to permit of the access and consequent activity of oxygen by reason of the greatly multiplied surface for its action. Now my proposition would be, that if coal could be mined or if mines could be found where under-cutting and loosening of the mass by some of the modern hydraulic or wedge-effect systems were employed, the coal could be brought to the surface in a fairly hopeful state for storage. But there is still to be considered the grinding effect of handling and transportation. A simple remedy would seem to reside in a systematic screening of the material at the yard or place of storage. That is to say, if the material were screened and possibly the lump portion sized and piled on the spot, with provision for using the dust and fine stuff as current fuel, there would be a fulfilling of the theoretical conditions at least. It would be further advisable to handle the lump portion by such mechanical methods as would produce the least abrasion, and to deliver it on the pile in small, well distributed masses; which are furthermore allowed to drop from the least possible height. One other condition would seem to call for mention. I doubt if there would be virtue in excessively large lumps, but rather the contrary, because of their tendency to cause open channels and pockets for the larger housing of air in the mass. Probably, therefore, that size of screened lump which would make the most compact mass, having the least ratio of voids to the total quantity stored, would most nearly fit the theory upon which our hypothetical performance is based.

I have referred in the foregoing paragraph to the hypothetical or purely theoretical character, but also mention has been made of the fact that what is theory to-day may be fact to-morrow. Something of this feature is already observed in connection with this method of procedure. In visiting the very large storage yards for Eastern bituminous coal at Milwaukee about a year ago, the most successful coping with fire troubles seemed to be in a yard where all the coal before piling was put through screens and the fine material kept separate from the rest, for such use or ready shipment as the circumstances might require. In the large storage pile of sized lumps from egg to six inch, no trouble from heating had been experienced.

Doubtless the most successful handlers and experimenters on Illinois coals, doubtless also the most extensive consumers, are the various plants of the Commonwealth Edison Company of Chicago. It is perhaps already safe to say that with them, at least, the method of

screening and storage substantially as outlined has passed the experimental stage.

I have in mind to mention but one other hypothetical method of procedure. This is based on the experiment outlined in Bulletin No. 46, which relates to the process of pre-heating or seasoning, whereby the initial activity is passed and the coal cooled down to a normal temperature again. The principle is not entirely lacking in proof; for many instances are familiar to all, of coal piles which, after heating and shoveling over have been cooled or quenched and repiled without further evidence of any tendency whatever to heat. To illustrate the theory I would outline a procedure somewhat as follows. Suppose that at the mine, the operator, to stimulate trade in the summer or dull season, would offer coal guaranteed to stand storage; and to carry out his end of the proposition should install a pre-heating or drying system by use of the rotary kiln or similar method. What would be the factors involved? First the heat necessary to carry out the process would be relatively cheap at the mine. The temperature would not exceed 212°F. and the discharge could be made directly into cars or in similar small masses where the tendency to cool down would be greater and more rapid than the tendency to continue any oxidation processes that might have been promoted in the drying process. Furthermore the drying out process would relieve the coal of an approximate burden of say 15% of its mass of water. The decrease in freight charges could very sensibly be added to the operator's charges in lieu of the loss of weight which he has suffered and, indeed, would be entirely offset so far as the consumer was concerned by the higher grade of the product he would receive. An additional premium could doubtless be added which would represent the added value on account of the storage qualities. Whether this factor could be sufficient to pay for the extra expense of maintaining and operating a drying outfit must be left to some one in the business to figure out. Incidentally it may be mentioned that the shortage or shrinkage of the coal in transit would be done away with. Rather on the contrary there would more likely be an augmenting of the tonnage over the mine weights.

The above attempts to illustrate in practice, what seems to be indicated in theory as a result of our studies here upon the storage of coal,, are given in the hope that at least here and there by some adventurous individual or corporation the sphere of experimentation will be transferred from the laboratory to the field of actual experience, where in the last analysis the work with real conclusions must be accomplished.

DISCUSSION.

Jahns: I would like to ask Prof. Parr whether a thorough soaking would be of benefit or otherwise to coal if in a situation where it would drain out again.

Parr: I have no doubt that if a system were devised for wetting the coal as put into storage, and the supply of water were kept up so that the surface of all the coal was continually kept wet it would answer the same purpose as submergence. There are two questions that arise, however. First, it is difficult to realize how much water it takes to wet up a coal pile. Second, there is the difficulty of keeping a mass of coal wet. Especially if heating begins, owing to the exudation of oily or tarry matter which bridges over and excludes the water from the areas most in need of it.

Hansen: I would like to ask how large a quantity of coal it is possible to pile before there is danger of combustion.

Parr: Most Illinois coal will not stand 8 or 9 ft. in depth, the depth being a factor of the time it takes a pile to cool off and keep from allowing the heat to run up to the danger point. If the pile is not too great and the temperature is not permitted to run up as high as 120 to 130°F. the pile is comparatively safe and while with Illinois coal 8 or 9 ft. is the limit, many Eastern types stand 20 ft and over.

Maury: Have you any information as to method of admitting steam by jets into the pile from below.

Parr: I have no data. I have already referred to the necessity of avoiding any source of external heat like that from steam pipes. As to the matter of discharging steam into coal there would be several difficulties, such as the necessity of keeping the jets going after once starting them. Upon cessation of the steam the conditions would be most favorable for starting up trouble. I would be very much interested to know if anything in this line has been tried.

Maury: If this preheating process be carried out at the mine and the coal delivered dry, suppose the coal becomes wet, what effect would it have on the coal thus treated?

Parr: Coal which has once been heated to a certain point and cooled down is negative, or immune to the action of oxygen at moderate temperatures. The only thing that is left to oxidize is iron pyrites, but this reaction alone will not generate sufficient heat to fire the mass.

Jahns: Does the system of ventilation prove beneficial?

Parr: The more ventilation the coal has the better chance it will have for oxidizing conditions. And unless the ventilation can be carried on so vigorously as to keep down the temperature it will do more harm than good.

Cumming: With reference to the firing of coal: I have been interested in the coal producing business. We at one time had a mine in Washington County. The coal from that mine was put in a pile and allowed to lie for 2 or 3 days. After a shower of rain came it took fire and burned. Some of the mines in Williamson County produce lump coal that can be stored. I cannot begin to tell you what the limit can be. It makes rather a difficult proposition but coal from central Illinois seems to fire the worst. I think you will scarcely find a mine where they are using mine run that does not take fire spontaneously, apparently due to the greater percentage of pyrites in the coal. I do not know any other reason why it should fire so much more readily. The coal in Williamson County assumes a yellow color on the top due to the spreading of the sulphur content.

Jahns: One question further. Regarding the remedy to be applied at the mines, what relief may we hope for from the practice of thorough screening of coal and then putting the finer grades through a process that is known as washing coal. I would like to know whether Professor Parr sustains that claim for such preparation of coal.

Parr: In the first place coals that are most successfully washed are usually of the harder varieties. In the next place washing takes out fine material. Remember further that the percentage of sulphur is higher in the fine than in the course. All these points are, therefore, in favor of the argument that screened and properly washed coal will bear storage. Throughout this community for at least 15 years that type of coal of 1 and 2 inch size has been stored with satisfaction in cellars with no instance of heat having generated under these conditions.

NITRITE REMOVAL TEST APPLIED TO MONTANA WATERS.

BY W. M. COBLEIGH.*

The results of preliminary experiments on a few Montana waters with the nitrite destruction test, described by Sellards in Water Survey Bulletin, No. 7, University of Illinois, are given in this paper. The method was followed as described, with the exception of a few modifications suggested by Dr. Bartow, under whose direction the method was developed.

The procedure is briefly described below. A medium was prepared by dissolving the following substances in a liter of water:

6 grams beef extract.
20 grams peptone.
2 grams gelatine.
.05 grams sodium nitrite.

The final reaction of the medium was adjusted to 2% acid (normal) before adding the sodium nitrite. The medium was sterilized intermittently for three days. The test was made by measuring five c.c. of the above medium into clean test tubes and sterlizing the same. The nitrite medium thus prepared was inoculated with 1 c.c. samples of the waters to be tested and incubated at a temperature varying between 37° and 39°C. for forty-eight hours. The nitrite was determined after incubation by the Griess method.

Complete removal of the nitrite in the medium often occurs. The point to ascertain is whether the destruction of the nitrite is a reliable indication that a water is contaminated with human or animal excreta. A great deal of definite information has been obtained on this point, by the results of experiments performed under Dr. Bartow and published in Water Survey Bulletins, Nos. 7 and 8, University of Illinois. The purpose of this paper is to show the results of practical experience with the method under conditions found in Montana. Incidentally, a few specific applications will be suggested, which no doubt have been thought of before.

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Bozeman is supplied with water by a gravity system. The city reservoir is fed by a large spring. Both the spring and the reservoir are in the mountains far above all human habitation. The city does not have control of the entire water shed, consequently a few cattle are pastured from time to time on the water shed. A very small amount of animal excreta is the only possible source of contamination and this is a varying factor.

Between Dec. 7, 1910, and March 22, 1911, nineteen tests of Bozeman city water were made at regular intervals. Samples were run in duplicate and there was no nitrite removal in any of the tests made between the above dates. Check samples of distilled water and of sewage were always used, to be certain that the medium was in working condition. In no instance did the sewage fail to remove nitrite and no removal was observed in any case where distilled water was used as a check.

During the month of April conditions changed and samples taken on the 4th, 11th, 21st, and 26th, all removed nitrite from the medium completely. The snow on the water shed was melting during this month which may have carried some contamination from the water shed into the water system. The normal bacterial activity of the soil was apparently not the cause of nitrite removal, because soil samples were collected in April from various points on the water shed. These samples were placed in funnels and leached with distilled water and the leachings did not have the power to remove nitrite. This is an important point in establishing the reliability of the method as a test for contamination.

On and after May 4th, samples of Bozeman water did not have the power to remove nitrite. In February of the following year there was a thaw and five tests were made to determine if the results of April could be duplicated, but there was no removal of nitrite. In all, thirty-two tests of Bozeman city water were made, extending over a period of six months. Twenty-eight of these tests gave no indication of contamination, while four point to the presence of a little contamination during a thaw.

With regard to the significance of the above results, it should be stated that Bozeman water is generally regarded to be above suspicion as a city water supply. Cases of typhoid fever rarely occur and all cases are easily traced to sources outside of the city. Prof. D. B. Swingle has made a number of bacteriological tests of the water and has always obtained a very low total count and never has found B. coli. Unfortunately, he did not make any tests during the month of April, 1911, when the water was showing power to remove nitrite.

A chemical analysis was made during the month of April, 1911, with the following results:

	Parts per million
Free ammonia	Trace
Albuminoid ammonia	.04
Nitrogen as Nitrites	None
Nitrogen as Nitrates	.3
Chlorine	None
Solids	168.0

So much for the experience with a mountain water of high purity. We now turn to the results with a contaminated river in a large valley.

The water supply of the city of Billings is taken from the Yellowstone river. This river is the outlet of Yellowstone lake in the National Park and is the main drainage channel for the valley through which it flows. This valley is one of the prosperous farming regions of the state and therefore the watershed is more or less contaminated, not only by farm habitations but also by human excreta from passenger trains which pass through the valley to the number of eight per day.

In addition the river receives comparatively small quantities of city sewage at each of five points above the intake of the Billings city water works. The first sewage to enter the river above Billings is at Laurel, fifteen miles away by rail.

Experiments with Billings water were commenced Dec. 7th and continued until April 21st. For each trial, samples were taken from the river at the intake to the settling basin, from the pumps which deliver water to the reservoir and from a water tap in the city. In all, twenty-seven tests were made and complete removal of nitrite was the result in every case.

The above results are very significant, when the following information is taken into account in connection with the description of the watershed. Prof. Swingle made tests for B. coli in all of the Billings samples and obtained positive tests in two cases out of the twenty-seven. However, it should be noted that he has occasionally obtained B. coli in the intake samples in other series of tests. That the contamination of the Billings water is a variable quantity is shown by the following data:

	Parts per Million Billings intake. Dec. 7, 1911.	Billings intake Dec. 15, 1911.
Free ammonia	.032	.067
Albuminoid ammonia	.085	.160
Nitrogen as nitrates	.25	.25
Nitrogen as nitrites	.0028	.0028
Oxygen required	.9	.8
Chlorine	8.6	10.2
B. coli	None	48 per c.c.

In all fairness, it can be said that Billings water has been looked upon with suspicion from time to time by the public, and it has not been uncommon for people to buy bottled spring water for drinking. There is much more typhoid fever in Billings than there is in Bozeman; but it should be stated that many such cases are brought in from the country for treatment. All facts considered, a careful study of the results with Bozeman and Billings waters indicate that the nitrite removal method has some considerable significance as one of the methods for judging the sanitary qualities of a water.

A few tests were made of the Yellowstone river at other points. On Dec. 28, 1911, four samples were taken at Livingston, a city one hundred and fifteen miles above Billings. One sample was taken at the intake of the city water works, another from the river directly opposite the intake, one from a city tap, and the last from the river two hundred feet below the outlet for the city sewage, which is emptied into the river without purification. No removal of nitrite was observed with the first three samples, but the fourth, taken below the sewer, gave complete removal. In this connection, it should be stated that during the month of December, little or no sewage enters the river above Livingston. What little there is comes from a summer hotel and a few private residences, and all of these are about fifty miles above Livingston by rail. The Livingston city water has never been suspected of being the source of typhoid infection.

On the day following the Livingston samples, seven samples were taken between Livingston and Laurel, covering a distance of one hundred miles. Five of these gave complete removal and two did not. All of these samples were secured above the Laurel sewer outlet.

It would appear that water from the Yellowstone river taken at points above sewage contamination will not remove nitrite and that sewage contamination gives it this power, when present in comparatively small amounts.

Bozeman creek is a mountain stream of high purity as it flows

through the canyon which it drains. On reaching the valley, it passes through a prosperous farming community, and, as a result, receives contamination from numerous barnyards and from a few privies near its banks. In many places manure piles extend to the water's edge. Its final course is through a portion of the city of Bozeman, to a point where it receives the city sewage and then flows to the East Gallatin river.

Several tests of water samples taken from the creek above human habitation show no removal of nitrite. Twenty-five samples taken at different points below habitation and below the contamination referred to above, extending over a period of four months, all gave complete removal of nitrite.

The sewage of the city of Red Lodge flows into Rock creek. Four samples were taken from Rock creek between the sewer outlet and a point fifteen miles below the outlet. All gave complete removal of nitrite and Prof. Swingle secured positive tests for B. coli with the same samples. For comparison, one sample was taken above the Red Lodge sewer outlet. At the time of sampling, it was supposed that Rock creek was not contaminated at this point. The sample, however, removed nitrite completely and also gave a positive test for B. coli. A more thorough inspection of the creek was then made and several privies at the water's edge were found, which were no doubt the source of the contamination indicated by both tests. This experience points to the conclusion, that a positive test with the nitrite removal method at least warrants that this information should be given due consideration in connection with the facts found by a sanitary inspection.

A few tests have been made with well waters and one is of special interest. Several members of a family were down with typhoid fever and the well water was suspected of being the source of infection. A chemical analysis gave very high nitrites and oxygen required. Prof. Swingle reported that B. coli were present and the sample completely removed nitrite from the medium. In this instance all three tests point to contamination.

The results of many of the tests, made to date, indicate that a very small quantity of contamination will give a water the power to remove nitrite. To determine the sensitiveness of the method, some tests were made with sewage diluted to various degrees. Complete removal of nitrite was always the result, even up to a dilution of 1 to 10,000,000. A sample of sewage taken Dec. 23, 1910, was allowed to stand in an open demijohn in the laboratory. Samples taken at intervals for ten days all removed nitrite. This would indicate that a sample for this test may give reliable results a long time after sampling.

Repeated trials showed that sewage treated with calcium hypochlorite did not remove nitrite. The bleach was added in the proportion of one part to eight hundred thousand, and was allowed to act two hours before sampling. This indicates that the method may prove serviceable in controlling the process of purifying water and sewage by calcium hypochlorite.

SUMMARY.

The data accumulated up to this time have not been obtained under a sufficient variety of conditions to warrant a definite conclusion as to the value of the method for routine water testing. The following tentative statements are made, subject to modifications after more experiments have been made:

1. All water samples which gave positive tests for B. coli removed nitrite from the nitrite medium on incubation.

2. All waters known to be contaminated by a sanitary inspection gave complete removal of nitrite. That these samples did not always give positive tests for B. coli is shown by the results with the Billings water.

3. The results with Bozeman city water indicate that more data should be secured for waters that are above suspicion from the standpoint of practical experience in order to determine more exactly the limiting conditions of the nitrite removal method.

4. The results with Bozeman water indicate that it would not be wise to condemn a water on the nitrite test alone. In case of a water like this, additional evidences of contamination should be obtained either from bacteriological examinations or from sanitary inspection.

5. In general, the tests made so far point very definitely to the conclusion that a water which will not remove nitrite is free from contamination. If this proves to be a safe conclusion, all water samples that give negative results with the nitrite removal method would not have to be tested bacteriologically. In all cases where positive nitrite tests are obtained, it would be safer in the light of present experience to obtain additional evidences of contamination from chemical and bacteriological tests before expressing an opinion.

6. Contaminated water samples seem to retain the power to remove nitrites for a considerable time after being taken. This is a distinct advantage in the shipment of water samples from a distance.

7. Water and sewage properly treated with calcium hypochlorite do not remove nitrites. This fact indicates the possibility of a very important use of the method in controlling purifying processes.

The writer is indebted to Mr. J. C. Bell for valuable assistance in

the laboratory work connected with the use of the nitrite removal method.

DISCUSSION.

Bachman: (By letter) This paper particularly interests me, as I have worked under the direction of Prof. Bartow as described in Bulletin 8, State Water Survey Series, on this "nitrite destruction test." I have found that the composition of the medium plays an important part in favoring or inhibiting the growth of certain organisms, i. e., peptone encourages and gelatin inhibits the growth. Prof. Cobleigh found that in the Billings water nitrite destruction followed when tests for B. coli were negative. At first thought the nitrite destruction test would appear to be more sensitive, because the Billings water supply is regarded with suspicion. Since the presence of B. coli is an index of fecal contamination, the medium must be made of such a composition as will favor B. coli. This can be accomplished by varying the quantities of gelatin and peptone in the media. Another important point which interests me is the use of the nitrite destruction test for the control of water and sewage purification devices. This test should be used in connection with the other presumptive tests for B. coli at water purification plants to ascertain its practicability. The test is very simple and at least confirms the other presumptive tests for B. coli.

THE NECESSITY FOR SAFE WATER SUPPLIES IN THE CONTROL OF TYPHOID FEVER.

BY ALLAN J. MC LAUGHLIN.*

Typhoid fever in the United States has been characterized, and not without reason, as a *national disgrace*. Certainly that portion of our typhoid prevalence which is due to *polluted water supplies is preventable* and our failure to prevent does not redound to our credit. The rather common use of sewage polluted water supplies without purification has been responsible for disaster in the shape of typhoid fever epidemics in our cities, with a frequency not pleasant to contemplate. Such supplies untreated and unfiltered would be exposed also to contamination from persons ill with or harboring the germs of *Asiatic cholera* should such persons gain access to the United States.

It is useless to expect that the *dejecta* of all persons ill with typhoid fever or cholera *will be properly disinfected* before reaching the sewers, especially if the contributor is a carrier who shows no signs of illness. It is evident that the surest and most prompt protection against waterborne disease can be afforded in each case by proper treatment or filtration of the public water supplies. With cholera, we have only the menancing possibility, but with typhoid fever we have the actual existence of the disease in such a high rate of prevalence that the United States suffers seriously by comparison with other civilized countries.

The *average American citizen* displays toward sanitary problems a *very dangerous apathy*. It is difficult to arouse his interest in anything so well known as typhoid fever. Cholera or plague or any scourge which to him suggests a quick and mysterious death will awaken his instinct of self preservation and arouse him to activity. Not so typhoid fever—it has been all about him always, excites no terror, and is viewed indifferently as an inevitable visitation which comes every year and takes its toll from the community. He never asks himself is this visitation inevitable, or may not typhoid fever be prevented or reduced? Twenty deaths per 100,000 probably represent

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200 cases of typhoid fever. Suppose 200 cases of Asiatic cholera occurred in any American city of 100,000 population, would not strenuous activity be displayed and very properly so, for the eradication of the scourge? Although typhoid fever mortality is lower than that of cholera, yet it is more dangerous in its transmissibility, more expensive in its lingering course and more disastrous in its sequelae than Asiatic cholera. The mental attitude toward typhoid fever, displayed by many physicians and especially health officers is scarcely more commendable. Their complacency in the face of typhoid fever rates of above 20 deaths per 100,000 population is difficult to explain. If the rate should be below 20 many municipal officials are inclined to boast of this low rate as compared with less fortunate cities.

What may be considered a low rate for typhoid fever?

Table 1 shows the death rates per 100,000 population in 10 large European cities. The average for 10 years is given in the first column. The average for 5 years in the second column. The other columns show the rate for the individual years from 1906 to 1910 inclusive. The figures are given for 10 years to show that the low rates are consistent and not a mere coincidence. These 10 cities represent a population of about 15 million persons, and the average death rate per 100,000 population for the 10 years was only 3.4. The rates are gradually getting lower and the rate for these 10 cities combined, with a population of 15 millions was only 2.5 in 1910.

TABLE I.

DEATHS PER 100,000 POPULATION. TYPHOID FEVER.

	Average 10 years, 1901-1910.	Average 5 years, 1901-1905.	1906.	1907.	1908.	1909.	1910.
Stockholm	1.7	3	2	2	1	5	1.8
Christiana	2.4	3	4	2	2	1.7	1.6
Munich	2.5	4	2	3	3	1.9	1.4
Edinburgh	2.9	8	3	3	2	1.2	1.3
Vienna	3.7	4	4	3	4	2.8	3.8
Hamburg	3.7	4	4	3	4	3.3	4.1
Berlin	3.8	4	4	4	4	4.2	2.9
Dresden	4.2	4	7	2	6	4.2	2.2
Copenhagen ...	4.5	8	4	2	7	2.7	3.6
London	4.7	8	6	4	5	2.2	3.3

Table 2 shows 15 other European cities which in 1909 and 1910 did not reach double figures in typhoid death rates per 100,000 population. These 15 cities represent a total population of over 9 millions.

The average rate for the total population was only 5.3 in 1909 and 4.5 in 1910.

TABLE II.

CITY.	TYPHOID FEVER DEATHS PER 100,000.	
	1909	1910
Frankfort	1.5	.9
Antwerp	1.0	2.3
Bristol	2.8	2.1
Nuremburg	2.6	
Birmingham	5.0	3.9
Belfast	5.2	3.9
Lyons	5.8	4.4
Leeds	7.2	3.8
Liverpool	8.4	3.9
Sheffield	9.4	3.0
Rotterdam	6.4	6.5
Amsterdam	3.8	6.7
Paris	8.4	5.6
Bradford	4.3	9.2
Leipsig	8.3	7.5
Total average rate	5.3	4.5

Table 3 shows the remaining 8 cities in Northern Europe with population in excess of 300,000. These 8 cities have a population of about 7½ millions. Their total average rate for 1909 was 13.9 and for 1910 15.6. These rates would be considered low in America, but the European officials consider the persistence of such rates to be a disgrace.

TABLE III.

CITY.	TYPHOID FEVER DEATHS PER 100,000.	
	1909	1910
Glasgow	12.5	6.5
Buda Pesth	9.4	13.6
Brussels	7.4	16.1
Dublin	15.7	12.2
Manchester	13.9	10.3
Moscow	13.8	15.0
Warsaw	13.5	17.4
St. Petersburg	25.2	33.7
Total average	13.9	15.6

To recapitulate, in Northern Europe, the 33 principal cities with an aggregate population of 31,500,000 had an average typhoid death

rate per 100,000 population of 6.5 in 1909 and 1910. This includes such notorious typhoid centers as St. Petersburg, which had a rate of 33.7 in 1910. The rate in St. Petersburg is considered disgraceful in view of the fact that the water supply is responsible. They have a supply partly filtered and partly raw Neva water. The bacterial examination of raw and filtered water showed little difference and during the cholera epidemic, cholera vibrios were recovered from both the filtered and unfiltered water. The filters removed only 60% of the bacteria in the raw water.

It is clear that in cities which have had safe water supplies for a period of years, the rate should not be above 5 per 100,000 unless some unusual condition exists, such as poor control of milk or lack of control over patients and carriers. Now let us compare typhoid fever rates in American cities.

Table 4 shows our honor roll for 1909 and 1910. These are the typhoid fever death rates among the 50 cities in the United States with more than 100,000 inhabitants. One city, Bridgeport, Connecticut, has a rate below 5. Three cities, Paterson, N. J., Cincinnati, Ohio, and Cambridge, Mass., have rates below 10 per 100,000,—22 other cities have rates from 11 to 20 deaths per 100,000, and the remaining 24 cities have rates from 20 to 86.

TABLE IV.

CITIES HAVING A POPULATION OF 100,000 OR OVER.	NUMBER OF DEATHS FROM TYPHOID FEVER PER 100,000 POPULATION.	
	1909	1910
Birmingham, Ala	59.7	49.5
Los Angeles, Calif	16.1	14.2
Oakland, Calif	11.2	16.5
San Francisco, Calif	13.9	15.7
Denver, Colo	24.1	27.5
Bridgeport, Conn	9.0	4.9
New Haven, Conn	20.5	17.9
Washington, D. C	34.3	23.2
Atlanta, Ga	50.6	50.1
Chicago, Ill	12.6	13.7
Indianapolis, Ind	22.3	28.5
Louisville, Ky	45.0	31.7
New Orleans, La	28.4	31.5
Baltimore, Md	24.9	42.0
Boston, Mass	13.8	11.3
Cambridge, Mass	7.7	9.5
Fall River, Mass	21.3	15.0
Lowell, Mass	10.5	19.7

Detroit, Mich.	20.5	23.0
Grand Rapids, Mich.	17.2	28.3
Minneapolis, Minn.	21.0	58.7
St. Paul, Minn.	18.9	19.5
Kansas City, Mo.	29.3	54.4
St. Louis, Mo.	16.2	14.9
Omaha, Neb.	36.8	86.7
Jersey City, N. J.	8.8	11.5
Newark, N. J.	11.9	13.1
Paterson, N. J.	9.7	7.1
Albany, N. Y.	190	14.0
Buffalo, N. Y.	23.8	20.4
New York, N. Y.	12.1	11.6
Rochester, N. Y.	9.4	13.7
Syracuse, N. Y.	11.2	28.2
Cincinnati, Ohio	13.3	8.8
Cleveland, Ohio	13.3	17.9
Columbus, Ohio	19.6	18.1
Dayton, Ohio	26.9	21.4
Tolédo, Ohio	41.7	37.2
Portland, Oregon	22.0	22.4
Philadelphia, Pa.	22.3	17.5
Pittsburg, Pa.	24.6	27.8
Scranton, Pa.	16.4	16.9
Providence, R. I.	11.4	17.9
Memphis, Tenn.	48.8	27.2
Richmond, Va.	24.1	21.9
Seattle, Wash.	23.8	14.2
Spokane, Wash.	43.2	45.4
Milwaukee, Wis.	21.4	45.7

These 50 registration cities in the United States have an aggregate population of over 20,000,000. The typhoid death rate in these cities for 1910 was 25.

TABLE V.

UNIT OF COMPARISON	AGGREGATE POPULATION	DEATHS PER 100,000 TYPHOID FEVER, 1910
Thirty-three principal European cities in Russia, Sweden, Norway, Austria-Hungary, Germany, Denmark, France, Belgium, Holland, England, Scotland and Ireland	31,500,000	6.5
Fifty American cities of 100,000 inhabitants or over	20,250,000	25.0
Excess of deaths typhoid fever in American cities per 100,000 population equals		18.5

So that on an average in every hundred thousand population we had compared with European results, 18 deaths (see table 5) and at least 180 cases of typhoid fever which should never have occurred. A conservative estimate for 1910 will place the deaths from typhoid fever above 25,000. When we consider that the smaller cities in America have in general higher rates than the larger; that the rural typhoid is high and in many sections higher than the urban; that in the sections not included in the registration area sanitary conditions are probably worse and typhoid fever rates higher than within the area; we are forced to conclude that a general rate of 25 is probably below the actual deaths from typhoid fever per 100,000 population in the entire United States.

The excess of 18 deaths per 100,000 in the urban population alone shows, that we have had in the 50 cities mentioned above, yearly at least, 3,600 deaths and probably 36,000 cases of typhoid fever which were preventable and should never have occurred. For the whole United States the number of preventable cases for each year by methods within our grasp, would probably reach 175,000, and the deaths so avoided would total 16,200.

In 1909 there were more cases of typhoid fever in the United States than cases of Plague in India, in spite of the fact that India's population is 2½ times that of the United States.

From January, 1907, to October, 1911, there occurred in Russia 283,684 cases of Asiatic cholera. This included the appalling epidemic of 1910. According to a conservative estimate there occurred in the United States during the same period one million and a quarter cases of typhoid fever, or more than 4 cases of typhoid fever in the United States for every case of cholera in Russia. We heard a great deal of the terrible ravages of cholera in Italy in 1910-11, yet in these two years there occurred in Italy about 16,000 cases of cholera and about 6,000 deaths, and in the United States in the same period we had more than a half million cases of typhoid fever and 50,000 deaths. We are accustomed to speak of these countries as pestridden, and a residence there or even a brief visit is considered with apprehension.

But do we consider the prevalence of typhoid fever in our country with sufficient seriousness? These 25,000 deaths do not represent our total loss. At a conservative estimate they are accompanied by a quarter of a million of cases of typhoid fever each year. These cases represent an average illness for each individual of four weeks and probably 6 or 8 weeks enforced abstinence from any gainful occupation. The economic loss is appalling. Computing the value of the lives lost to the community, the cost of medical attendance and hospital

care, the loss of earning capacity for many weeks, the decreased earning capacity and impaired efficiency due to sequelae, this loss would reach a sum of not less than $100,000,000 annually.

To understand fully the menace of typhoid fever, one must remember that it cannot be prevented by ordinary personal cleanliness as typhus fever may be prevented, and is not confined to the poor and dirty, but reaches all classes.

It is not something we have in childhood and consign to history as scarlet fever or measles, but a disease which attacks the most robust adult individuals during the period of their greatest activity and their greatest economic value to the community. Typhoid fever is a disease against which the individual is helpless,* and the protection of the individual can only be effected by sanitary control of the entire food and drink supply and the sanitary disposal of human excreta.

Time will not permit me to discuss the whole problem of typhoid fever transmission, and I shall confine myself to the waterborne typhoid solely. I do this with a full appreciation of the great importance of the other factors in typhoid transmission: viz., milk, control of patients and carriers, contact, flies and rural typhoid.

No single measure in reducing typhoid on a large scale approaches the effect of substituting a safe for a polluted water supply. As an instance of this wholesale saving of human life, the reduction of typhoid fever in Pittsburg may be cited. Since the installation of the Pittsburg plants there has been an annual saving in the city of Pittsburg of 400 lives from typhoid fever alone. Installation of safe water supplies in America has not always produced such brilliant results, but the failure to reach the low figures attained by the Germans is due principally to three things: first, failure to supply pure water to all; second, imported cases, usually from communities which are typhoid centers; third, existence of insanitary conditions such as contaminated wells, out-door privies, and lack of control over milk and excreta. As an instance of high rate due to failure to furnish filtered water to all the people, the experience of Pittsburg is interesting.

The filter plant in Pittsburg was first put in operation, November, 1907. But a small portion of filtered water was supplied at first and this was mixed with the unfiltered supply. The amount of water filtered was increased until October, 1908, when the supply of that part of the city between the rivers, about three-fifths of the total

*Vaccination against typhoid protects the individual in the great majority of cases. As a general means of protection of the civilian population, it is not likely to prove practicable, however, although of immense advantage in protecting military units against typhoid where compulsory vaccination is feasible.

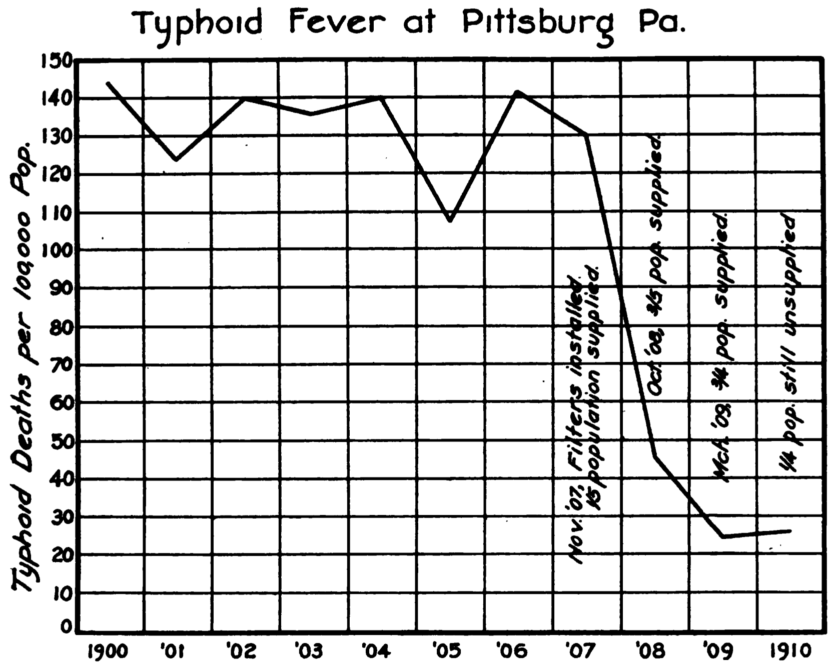
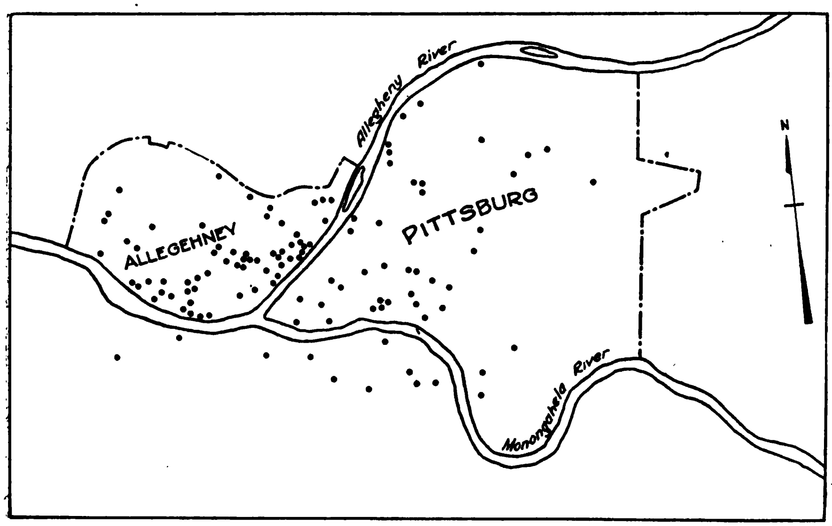


Chart No. 1.



Distribution of Typhoid Fever Deaths 1910.

population, was filtered. The south side, a little less than one-fifth of the entire population, was supplied with filtered water in March, 1909. The former city of Allegheny, recently annexed, is not yet supplied with filtered water. This part of the city includes a population of about one-fourth of the entire city.

Chart No. 1 shows the remarkable decrease of typhoid fever in Pittsburg progressively coincident with the increase of area supplied with filtered water. In spite of all this remarkable reduction, two points stand out prominently, first the rate is still high (1910), and second, the seasonal distribution suggests water as a prime factor. Explanation of these two points is furnished by the map. After a study of the spot map, it is clear that water was responsible for the high rate, as this high rate was due entirely to the abnormal rate in wards 21 to 27 inclusive.

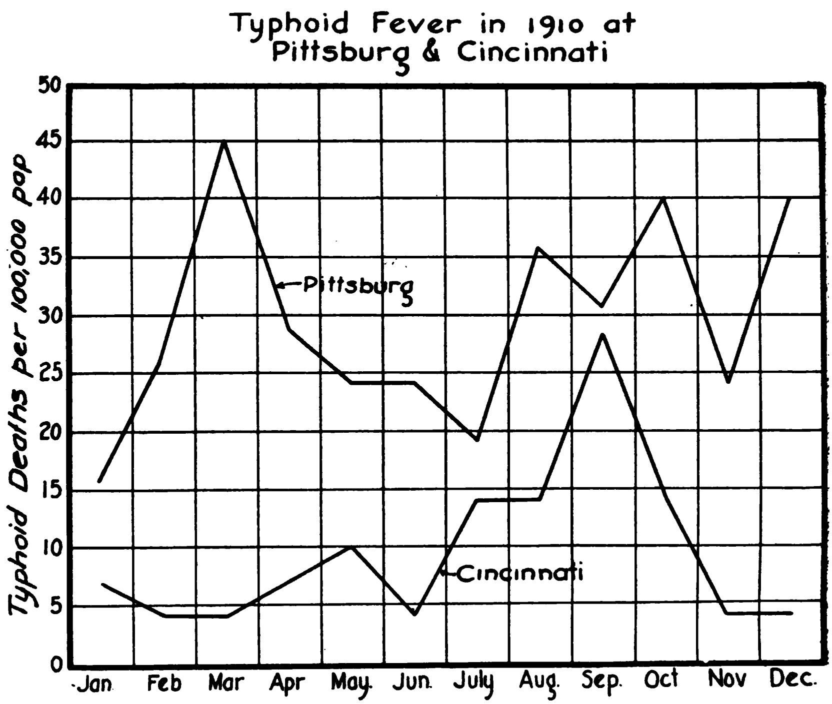


Chart No. 2.

Chart No. 2 shows Pittsburg compared with Cincinnati. The seasonal prevalence in Pittsburg suggests water. The very high peaks in March and December are noticeable in contrast with Cincinnati's normal curve.

TABLE VI*.

CITY OF PITTSBURG, PA.

	POPULATION	TYPHOID DEATHS		POPULATION	TYPHOID DEATHS
Ward 1........	11,623	3	Ward 15........	20,141	3
Ward 2........	14,386	1	Ward 16........	20,833	1
Ward 3........	26,462	3	Ward 17........	25,213	3
Ward 4........	25,055	11	Ward 18........	17,994	1
Ward 5........	24,495	2	Ward 19........	23,482	3
Ward 6........	26,261	3	Ward 20........	18,648	2
Ward 7........	13,263	1	Ward 21........	22,506	11
Ward 8........	18,204	0	Ward 22........	15,716	9
Ward 9........	17,795	6	Ward 23........	21,799	13
Ward 10........	21,205	3	Ward 24........	17,354	6
Ward 11........	17,066	2	Ward 25........	16,037	5
Ward 12........	22,342	2	Ward 26........	15,291	6
Ward 13........	24,080	2	Ward 27........	23,580	12
Ward 14........	13,074	1			

Total population of Pittsburg: 533,905.

Total deaths, typhoid fever, 115.
Death rate per 100,000, entire city—21.3.
Death rate per 100,000, wards 1-20—13.4.
Death rate per 100,000, wards 20-27—46.9.

Wards 1 to 20 (see table 6) were supplied with filtered water. The aggregate population of these 20 wards was 401,622. The typhoid fever death rate per 100,000 in 1910 was 13.4. Wards 21 to 27 comprise the old city of Allegheny and have a total population of 132,283. This section received unfiltered water. The typhoid fever death rate per 100,000 in this section in 1910 was 46.9.

The absolute necessity of a safe water supply (and by "safe", a supply is meant which is safe 365 days in the year) in seeking to rid ourselves of the odium of water-borne typhoid, is obvious. The installation of such a supply, however, has another powerful effect

*These figures were furnished by the Health Department of the city of Pittsburg.

*The householder is as a rule unwilling to close his well and connect his premises with the public water mains unless the city water appears to be better than that obtained from the well. When water connections have once been made, water closets or other suitable toilet facilities are usually installed as a matter of convenience and the yard privy is no longer needed and its use, therefore, is discontinued.

upon the typhoid fever rate. The existence of a pure public water supply makes possible the elimination of the dangerous shallow well, and filthy yard-privy. With a contaminated or unsightly public supply, a vigorous campaign against the insanitary privy and contaminated well is impossible.

The conditions which make disaster possible where the source of public water supply is polluted are two, viz:—

1. Failure to purify.
2. Inefficiency of the purification.

The failure to install a purification plant is usually due to an undue confidence in a water supply which is safe "most of the time". It is difficult for some officials to understand without a severe lesson that it is not sufficient to have a water supply that is safe for 360 or 361 days in the year, and to these officials it seems scarcely justifiable to require expensive purification for the sake of the 4 or 5 days in the year during which, due to weather conditions, pollution may take place. Such a supply with a favorably placed intake may escape pollution for more than a year. There was no evidence of serious pollution of the water supply of the city of Erie, Pa., during the year 1909, yet the appalling disaster of January and February, 1911, showed that pollution could take place under certain weather conditions.

There is also too much confidence placed in unfiltered surface supplies from inhabitated watersheds. Even where there is alleged control of the watershed and ample storage, pollution may occur. In regard to unfiltered surface supplies, the need of bacteriologic control is very evident. Dangerous pollution may be present only for a few days or for a few hours. This is most likely to be disastrous in time of drought or low water; at such times the diluting effect of the inflow and the purifying effect of storage are both reduced to the minimum. The bacterial count per c.c. is valuable, but the quantitative estimation of B. coli is of far greater importance. A low count does not necessarily imply a safe water, but a low count coupled with absence of B. coli may be considered an index of safety.

The typhoid epidemic in Baltimore* in 1910 was coincident with a prolonged drought. The run-off from the watershed of the Gunpowder river was reduced to the minimum. The sewage pollution was thus concentrated and gross pollution was evident upon bacteriological examination. B. coli was frequently found in 0.1 c.c. and sometimes in 0.01 c.c. samples. When the run-off increased, afford-

*Ford, Wm. W., and Watson, E. M. Bulletin Johns Hopkins' Hospital, October, 1911.

ing greater dilution and increased storage, the water returned to normal and the typhoid fever dropped to a minimum.

In Europe surface supplies are almost invariably filtered, and eventually such supplies in America will be treated or filtered. For the present we are willing to gamble.

Poor filter efficiency is often responsible for disaster in the shape of typhoid outbreaks and may be due to several causes. The slow sand type may give poor filter efficiency when sufficient extra units are lacking, necessitating excessive rates, and placing of "green" filters in service. Excessive rates, too little coagulant, insufficient sedimentation capacity and insufficient storage are common operating and structural faults of the mechanical type. Sometimes a properly constructed plant is struggling with a raw water which has a very high bacterial content and even with fair filter efficiency yields an unsafe effluent. Probably the greatest single cause of a poor effluent from filter plants is inefficient operation by unskilled men. It is absolutely essential for good results that bacteriologic examination including B. coli estimation be made at least once daily, and in slow sand plants from each unit separately. The man in charge must be able to do this. In mechanical filter plants or with hypochlorite plants, he must also have the necessary skill to adjust his chemicals with nicety according to the changes in the raw water. With such a man in charge of a properly constructed plant, a safe effluent is assured at all times. When struggling with a bad raw water he will use with fine judgment hypochlorite as an adjuvant with good results. He will study the peculiarities and fluctuations of the constituents of the raw water and adjust his treatment accordingly.

The most serious defect in sanitary control of our water supplies is the lack of proper daily bacteriologic examination of the water and quantitative estimation of the B. coli content. In some of the lake cities there is proper daily bacteriologic examination of the water supply, but in many of them there is either an imperfect examination or none at all. One lake city with a slow sand filter plant of three units and a consumption equal to the safe filter capacity of the beds, operates these without rest, putting the units in service "green" and with an occasional examination of the water once or twice a month. This city had a typhoid death rate of over 300 per 100,000 in 1910. One large city using unfiltered lake water is so sure that the water is pure that examination is only made occasionally. One of the largest lake cities using an unfiltered supply exposed to sewage pollution, makes a bacterial count daily, but restricts its effort to detect sewage pollution to the antiquated and indefinite test of inoculating a guinea pig occasionally with a small portion of a broth culture.

It is the plain duty of a municipality to provide its citizens with pure water. It is not sufficient to warn against a supply as dangerous and advise its use only for fire, lawn sprinkling or factory purposes as at Flint or Saginaw. There are many people in every city who are like children and must be protected even against themselves. The lazy, poor and ignorant will drink and use the polluted public supply from a convenient tap rather than travel a considerable distance to a pump or buy bottled water, which they can ill afford. Neither is it sufficient to have a safe supply for 360 days out of the year, warning the people to boil the water on the other five days. The notice to boil the water is based on bacteriologic findings which are 24 hours late. The notice is often ineffective in reaching the intelligent and is quite as often ignored by the ignorant. Typhoid fever contracted by such an ignorant, careless or lazy individual unfortunately does not stop there; but he becomes a focus from which many other cases may be derived.

The factors affecting sewage pollution of a water supply and which determine the relative danger to be anticipated from such pollution are:

The amount of polluting material, the presence of pathogenic organisms, the time of transit from the source of pollution to the water works intake, and the amount of water available for dilution.

Provided the amount of polluting material is considerable, that typhoid fever is prevalent on the watershed, and that the time of transit is within the bounds of time deemed necessary for the natural death of bacteria, pollution of the intake will take place. The last factor, the amount of dilution, will determine the intensity of the pollution. If the polluting material is great in amount, and if a swift current cuts down the time of transit, prevents sedimentation, and retards dilution, then gross pollution results.

With a dilute pollution one need not expect a great explosive outbreak, but many cases of typhoid may result, especially following floods and rains. Often in the absence of explosive outbreaks in the winter or spring months, it will be demonstrable that too many deaths from typhoid fever occur in the first half of the year. On the other hand, it is reasonable to suppose that the dilute infection may be responsible for many scattered cases which can not be traced to water. These cases may not appear in sufficient numbers in any particular month to be remarkable or they may be obscured by occurring in the months when typhoid fever is accepted as an inevitable visitation.

Water may be responsible for many cases of typhoid when it is impossible to prove the case against it. We are able to fix the guilt on the water supply only in massive outbreaks of explosive character,

but smaller doses of pollution can be responsible for smaller outbreaks of many cases spaced over a long period without any hope of proving this causation.

When cities have a public water supply polluted by sewage or admittedly exposed to pollution, the obvious thing to do is to filter or treat the water and protect the public from infection. Unfortunately there is a deplorable tendency to abuse the town up stream and to spend years in an effort to compel (usually without legal process) sewage disposal in the offending municipality. In other cities where the pollution is due to their own sewage, years are lost in discussion of methods of sewage purification, while the dangerous untreated and unfiltered water is furnished to the citizens.

In regard to sewage disposal it must be remembered that no general rule can be formulated which will cover with justice every case. Each municipality becomes a separate problem and local conditions must be studied. Remedies for correction of improper sewage disposal will differ according to the local conditions. Even if all the sewage from our large cities and towns was prevented from reaching the lakes and rivers, it would be impossible to prevent pollution from reaching these waterways in times of storm and flood, so that sewage disposal even carried to the degree of sterlizing the effluent does not give us a substitute for water filtration or treatment. While it is impracticable to prevent pollution of the Great Lakes, it is possible and imperatively necessary that such pollution be controlled and kept within safe bounds. It would be very foolish from an economic standpoint not to avail ourselves of the cheapest and simplest method of sewage disposal, viz: disposal by dilution, provided that this may be done without danger to the water supplies of other communities and without putting an unreasonable burden and excessive responsibility upon the filter plants of those communities. The point to which this method of disposal may be permitted must be determined by local conditions. There is a crying need in the United States for official standards of drinking water. These should fix the permissible number of bacteria in both raw and filtered or treated water. I do not care to attempt to fix such a standard but, in my opinion, the bacterial count in raw water from the Great Lakes should not exceed 5,000 per cubic centimeter at any time and should not average above 1,000. Filtered or treated water should not contain more than 100 organisms per cubic centimeter at any time and the average should be 20 or under.

In view of the fact that bacterial counts may be low in a comparatively dangerous water, and sometimes a high count might be found in water containing no evidence of fecal bacteria, the colon estimation is of primary importance in judging the character of a raw

water. There should be standards for the permissible colon content of raw water. These should be fixed after careful study of the ability of filter plants and other processes to remove colon and other fecal bacteria. These standards for raw water and for filtered or treated water would enable us to strike a balance between sewage purification and treatment of water, and to determine the degree of sewage purification necessary to assure a raw water of reasonable quality at a given point. These standards would also mark the extent to which disposal of sewage by simple dilution might be permitted with safety. As a general proposition, it is cheaper to treat drinking water than to purify sewage. The economic side of the question must be considered. How far is it necessary to carry the treatment of sewage as an adjunct to water purification. The balance between these two powerful agencies in the protection of the public health must be struck and as intimated above, this must be done separately for each local problem and no definite rule for the relation of these agencies can be made.

These sewage problems are often difficult of solution—present great engineering difficulties and necessitate the expenditure of large sums of money. This means that much time must elapse before the proper method is selected and a great deal more time will pass before the works are completed. In the end, though necessary, the sewage purification does not remove all pollution and treatment of the water supply is still a necessity after the sewage disposal plant is in operation. On the other hand the dangerous public water supply is a simpler proposition. Immediate protection can be afforded by treating with "hypochlorite", using a temporary plant, until the method to be finally adopted is decided upon. In a word, there is every excuse for deliberation and reasonable delay in settling the sewage disposal problems; while there is no excuse whatever for any municipal government to delay in applying the remedy which protects immediately viz: treatment or filtration of the public water supply. Sewage disposal measures for improving the quality of the raw water for preventing its deterioration or for other reasons may be undertaken when necessary and feasible.

To summarize briefly, the writer wishes to accentuate the following points:—

1. In the prevention of typhoid fever there is a necessity for safe water supplies for 365 days in the year.

2. Unfiltered surface supplies may be exposed to a dangerous pollution for a few days or even for a few hours only.

3. Supplies derived by impounding surface waters and which depend upon storage alone to nullify the pollution of an inhabited watershed may be very dangerous in periods of drought and low

water. The proportion of pollution is relatively greater at such times and the time of storage is greatly reduced.

4. Purification whether by storage, filtration or chemical treatment must be efficient at all times and this cannot be assured without daily bacteriologic control.

5. It is essential that a daily quantitative estimation of B. coli be made, as a low bacterial count does not necessarily mean a safe water without absence of B. coli.

6. There is a necessity for close supervision of municipal plants by the state to correct structural and operative defects and ensure a safe water at all times.

7. Bacteriologic control and state supervision would ensure cleaning when necessary and should prevent the putting in service of slow sand filters before the "schmutzdecke" is "ripe".

8. In order to control typhoid fever and eliminate water-borne typhoid it is not sufficient alone to have a purification plant. In addition the purification must be efficient and the purified water must be available in all parts of the city.

9. The danger of dual water supplies is apparent, especially if the polluted supply is easy of access and the safe supply difficult to reach or expensive.

10. In protecting the public health, purification of the public water supply is usually primary and sewage disposal secondary, but often a judicious adjustment of the two agencies is necessary, especially for economic reasons. Sewage disposal will rarely if ever make a sewage polluted water supply absolutely safe, but often is an aid and sometimes a necessity to furnish a reasonably good raw water for the purification plant.

DISCUSSION.

Hansen: What water purification plant is that to which you refer?

Dr. McLaughlin: Ashland, Wisconsin.

Orvis: What was the rate for Pittsburg prior to the installation of filter plant?

Dr. McLaughlin: 130.

Jennings: At Quincy, Ill., a town of about 35,000, about one-third of the population is supplied with water from cisterns. During a recent investigation I made of the water supply of Quincy for the City Council, I found that it was almost a universal practice to have both the privy vault and cistern as close to the kitchen as possible. In several instances it was almost possible to touch the pump handle of the cistern while standing in the door of the privy. At one place the privy vault was within 12 feet of the cistern and at another there

was a group of three privies less than 15 feet from the source of the drinking water supply for the family. About a year ago the City Council passed an ordinance against the use of cisterns, but it has never been enforced. Within the last month one of the councilmen, who is up for re-election this spring, introduced a resolution to annul this ordinance as it was working a hardship on the property owners. It is wonderful what politicians will do in their effort to continue their regime in handling city affairs. This step alone should be sufficient grounds for defeating any man.

Bartow: I might mention a local incident pertinent to Dr. McLaughlin's paper. The city of Rock Island put in a filter plant a little more than a year ago. The plant was about ready to go into operation at the time of the spring thaw when ice was to go out. In order to save the citizens from the bad water the filter plant was put in operation on February 15th, and it was published in the papers that the filter plant was running. The citizens began to use, as they supposed, good water. But this filter plant puts filtered water into a reservoir of 12,000,000 gallons capacity which contained poor water, and in addition all the mains were filled with the poor water. Typhoid fever was noticable two weeks after the filter plant was put in operation. (See diagram.) Alarmed, the authorities sent water to the State Water Survey. The water reached us about four weeks after the

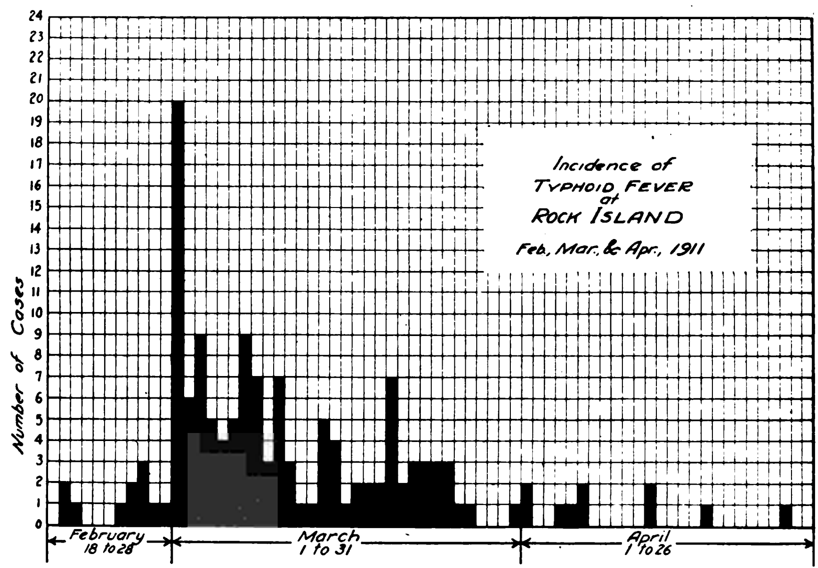
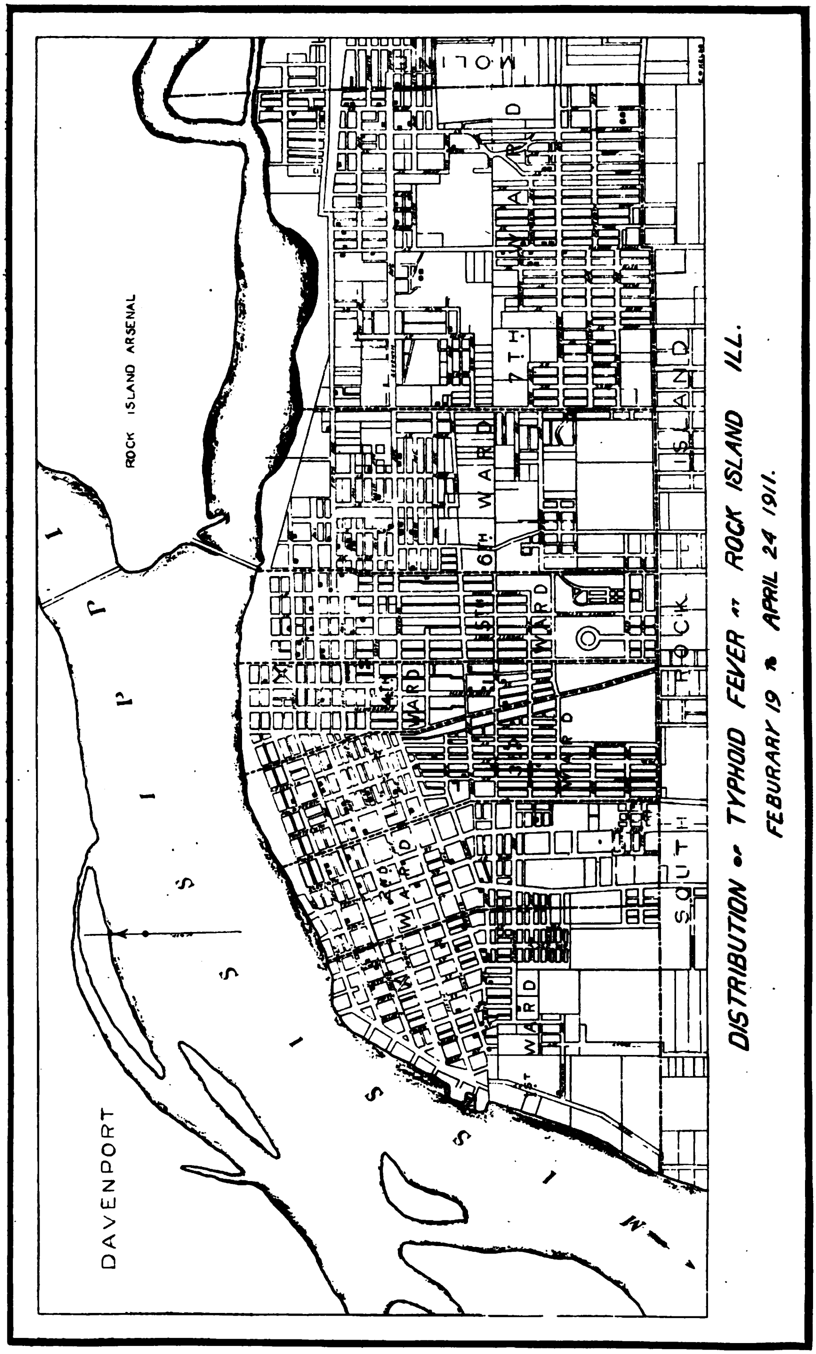


Diagram. Incidence of Typhoid Fever at Rock Island.



Map. Distribution of Typhoid Fever at Rock Island.

filter plant was put in operation, and it takes us about one week to make the analysis. On the 13th of March water collected was reported good. On the 15th they shut down the filter plant and began pumping poor water into the reservoir. As a result, during February, March and April 140 cases of typhoid fever with 14 deaths were reported. This year the plant is running in good condition, under competent chemical and bacteriological control, and up to the present time I believe there are no cases. This typhoid was evidently water borne. The cases were widely distributed. (See map.) In Moline, a city adjoining Rock Island, where they used filtered water throughout the whole year, only 2 or 3 cases of typhoid fever were reported during the time Rock Island had 140

Dr. Norbury: From the standpoint of a physician, I am interested in the sanitary aspects of this subject. As a member of the Board of Administration having charge of the sanitary service of our seventeen charitable institutions with a resident population of over 16000 patients and inmates, and 2500 employees, I am made aware of the fact that to obtain a wholesome water supply is one of our most important and formidable problems.

The presence of an epidemic of typhoid fever in an institution at once suggests the necessity of a sanitary survey of the water supply. We have had such epidemics during the past year. Mr. Hansen made a sanitary survey of two of these institutions and from the valuable suggestions made by him, together with the great help given us from the laboratory under Dr. Bartow's direction, we are able to plan a campaign of procedure to meet the sanitary preventive and therapeutic demands. We should seek farther than the water supply, however, in search for the causes of an epidemic. The chief possibility as an etiological factor, being the presence in an institution of a "typhoid carrier". We found one in one of our institutions. Segregation is imperative when such a source of infection is found.

Many Illinois institutions are dependent upon a water supply coming within the range of both polluted streams and infected wells. To meet the dangers of such unwholesome and inadequate source of supply the State is now preparing at one institution to expend considerable money to insure a constant and sufficient wholesome supply of water. In the future location of new institutions in Illinois the sanitary survey will be paramount, I am sure, in seeking to meet the demands of such institutions for a pure and abundant source of water supply.

I remember as a student in Philadelphia during the Plymouth epidemic, how the sanitary aspect of this public health calamity was presented to the student body, and a brief historical review of the

evolution of our knowledge of typhoid fever being a filth disease and its specific germs being especially found in polluted water supply. The history of the regeneration of Munich under the persistent campaign waged by Pettenkorfer was the great example set before us.

Dr. Hurst: Dr. McLaughlin says especially that water purification is the first consideration. I think sewage disposal is the second. As early as the year 1875 in England they first considered sewage disposal, and I think sewage disposal in this country will solve the problem of water purification.

Dr. McLaughlin: It is true that sewage treatment has been very prominent in the sanitary history of England and the English have made great progress in this direction. These sewage disposal plants have been a necessity in most instances to obviate nuisance, and were installed usually with that object in view. They have never in recent years depended upon sewage treatment alone for the purification of a water supply. They sometimes use sewage purification as an adjunct, but in practically all cases it is the English practice to filter surface water supplies.

The gentleman has evidently misunderstood the English attitude toward public water supplies. They have paid great attention to sewage disposal, but have not neglected to make their public water supplies safe by filtration, whenever such supplies were derived from surface sources.

Orvis: Would not sewage disposal plants practically take care of water from the Great Lakes.

Dr. McLaughlin: In spite of the best measures of sewage disposal which are economically feasible in the cities of the Great Lakes, pollution of the lakes will occur. The boundaries of the zone of polluted water near shore are variable and inconstant, due to winds and currents. Under these conditions the only sure way of securing safe water every day in the year is to filter or treat the public water supply.

Sewage purification is not a substitute for water purification, although it is often an aid and sometimes a necessity in securing a good raw water.

Mr. Henderson: I should like to ask the Doctor if the people in those wards in Pittsburg are still supplied with raw water. The chart on the left shows that the rate would be approximately 140 per one hundred thousand using raw water in the whole city and since that time the other chart shows it 46 in those wards still supplied with the same water. Has the reason been discovered.

Dr. McLaughlin: The reduction in Allegheny is from about 100 to 46 in spite of the fact that the unfiltered water is still used. This is

probably due to the fact that the notoriously bad character of the water has been widely advertised and the more intelligent citizens do not drink this water without boiling. There are still many people who do drink this water as evidenced by the fact that the rate is 46.9 in wards 21 to 27, and only 13.4 in wards 1 to 20.

Spaulding: I would like to have the Doctor explain again about the dots in the Pittsburg survey; I did not understand the explanation.

Dr. McLaughlin: Dots on the map signify deaths from typhoid in 1910. One-fourth of the entire population received unfiltered polluted water and the death rate per 100,000 in Allegheny is 46.9 and the rest of the city is 13.4.

Spaulding: With reference to that three-fourths as being supplied with filtered water. The dots indicating typhoid cases or deaths are much thicker in one corner than in other portions of the city.

Dr. McLaughlin: That is a question of population. That part is the most thickly settled part of the city.

Spaulding: Is it the residence portion of the city?

Dr. McLaughlin: Mostly commercial houses, tenements, etc.

Dr. Park: I would like to know if that list of European cities are dependent on the filtered water.

Dr. McLaughlin: You find various sources of supply in these cities and I can answer by saying they get pure water by using artesian water without filtration, or if they use surface water they filter it. I do not wish to be misunderstood, and I wish to bring out clearly that there are other factors having enormous weight in typhoid transmission.

Spaulding: Is it not entirely probable that by correcting these other factors which might be a large element in making this difference, it might change these comparative figures a great deal. In other words you are estimating, are you not, the weight of the various factors, say there are three or four, you seem to be making water the largest factor, larger than the other two or three.

McLaughlin: I want to draw attention to the fact that if you have a polluted water supply it is your duty to correct it, and then find out how much typhoid you have left.

Spaulding: Would this be right: That because those figures for European cities show a lower death rate it does not necessarily mean that their water supply is better than the American cities which show a higher rate?

Dr. McLaughlin: I have tried to show that these typhoid fever death rates were much lower than American cities, and that in general their water supplies were better.

These same cities, notably Hamburg, Munich, Berlin and others, formerly had polluted water supplies and high rates for typhoid fever.

TYPHOID FEVER AND THE WATER SUPPLY OF MATTOON.

BY R. A. GABBERT.*

It was my privilege a few years ago to be a member of a committee whose duty it was to investigate the water supplies, facilities and management of water works of other towns and cities, with a view, if possible, of finding some method and offering some suggestion for the increase and betterment of Mattoon's water supply.

In making the investigation I came in touch with a great many men who were familiar with the water question, and I became much interested in the subject.

In following up my investigation I became acquainted with your Secretary, Dr. Edward Bartow, who very kindly rendered me some very greatly needed assistance.

The acquaintance resulted in Dr. Bartow's asking me, as a layman or business man, to read a paper before your Society.

The data that I have gotten together on the subject assigned me, I shall endeavor to present in the way a layman would deal with the question, as a business proposition, from the citizen's standpoint.

If we were dealing with the commercial phase of the water question in Mattoon, our paper would not be complete without a report on the Water Works & Reservoir Company's plant, but they furnish water for commercial purposes only.

According to the records of the City Clerk of the City of Mattoon, beginning with the date of January 4, 1900, and running to September 1, 1911, 11 years and 8 months, there were 34 deaths from typhoid fever in the city.

It can be readily proven by the records of the City Clerk and the Mattoon Clear Water Company that not a single person, whose death was caused by typhoid fever during the 11 years and 8 months referred to, used water from the Mattoon Clear Water Company's mains exclusively. They did use water from surface wells, which were contaminated, as tested so far, and possibly responsible for the mortality.

During the first week of October, 1907, three persons from one

*President Chamber of Commerce, Mattoon.

family died from typhoid fever; all were using water from a surface well that was afterwards found, by analysis, to be polluted.

The three cases referred to represent almost 10% of the total number of deaths from typhoid fever during the 11 years and 8 months.

Eight persons died from typhoid fever from 1904 to 1907, who were using water from surface wells, that were afterwards found, by analysis, to be contaminated.

No doubt an investigation of typhoid fever and the water supply of other towns would show practically the same condition prevailing.

We hear a great deal about conservation of natural resources, conservation of property from loss by fire and conservation of many other kinds, but hear very little of the more important question—conservation of life from death by typhoid fever.

A proper and healthful supply of water placed within the reach of every citizen would no doubt reduce the typhoid mortality to almost nothing. A careful working out of public water systems, under strict state supervision and inspection would reach this end.

It is not only towns and cities that get bad water from surface wells, but the country also comes in for its share.

During 1911 water from wells of 9 school districts in an Illinois county was analyzed and found to be bad in every case, and the water in three of the wells was found to be unfit for use.

Perhaps a more careful inspection of water from surface wells and a greater publicity given to its condition would bring about a better condition of the water supply.

About 800 of the 3000 families living in the city of Mattoon get water for domestic use from the Mattoon Clear Water Company, and the balance are supplied entirely from surface wells.

Water furnished by the Mattoon Clear Water Company comes from tubular wells 60′ to 90′ below the surface, in sand and gravel overlaid by 40 to 60 feet of hard pan. Water taken from these tubular wells has been analyzed by the State Water Survey of the University of Illinois, on innumerable occasions, and has always been found to be healthful and satisfactory for domestic uses.

Water from a water bearing stratum of sand and gravel, overlaid by hard pan, 50 or more feet below the surface, must be, for domestic use, much superior to water, even though filtered, which is taken from sluggish streams and reservoirs having mud bottoms. Natural filtration through a long course of sand and gravel overlaid by hard pan must be safer than any system of artificial filtration.

Water from small streams and rivers passing through flat countries, such as the Illinois prairies, namely, the Vermillion, Embarass, Okaw and Sangamon rivers, must be more or less polluted for many

reasons. It is not an unusual case for a cemetery to be located on the banks of rivers, and near where water supplies are secured.

It must be reasonable that seepage water alive with disease germs would reach nearby streams from such sources.

In support of this theory I refer to a report of the Burr-Herring-Freeman Commission of the water supply of New York, after conducting experiments upon the travel of pollution.*

In further support of the same theory, I refer to a German experiment† reported by Chas. B. Burdick.

A Mattoon druggist sold to a farmer some Carbo Creso for disenfectant purposes. He used it on some hogs that were kept in a lot about 300′ from his house well. There was a pool of water in the hog lot. A few days after using the disinfectant the water in his house well tasted very strongly of it. Before the water was fit for use the hog wallow had to be filled up and the well thoroughly cleaned.

The same druggist used some Carbo Creso in a cess pool 80′ from the well from which he secured water for domestic uses. Soon after the Carbo Creso was put in the cess pool the water was found to be contaminated with it. The use of water from the well was immediately discontinued.

There is no doubt in my mind that pollution will travel a considerable distance through the ground, so much so, that a water supply within two or three hundred feet of cess pools or cemeteries are liable to pollution.

When it is not possible to secure a satisfactory water supply from subterranean sources, the establishment of a filtration system should be imperative.

Conditions in the general water supply of the State of Illinois have greatly improved in the past few years, and much credit is due to the State Water Survey.

A successful solution of the water supply problems of Illinois would be obtained if the scope and authority of the State Water Survey was enlarged, and it was furnished with ample means to carry on a more general campaign of water inspection and supervision.

It is to be hoped that at no far distant date, wise and far reaching legislation will be enacted, which will give to the State Water Survey full and complete authority, with ample means to carry on such a campaign, and with authority to enforce its findings. It is only after such authority is given and made enforceable that we can hope to reach and successfully combat the dread disease of TYPHOID FEVER.

*Proc. Ill. Water Supply Assn., 1910, 43.
†Proc. Ill. Water Supply Assn., 1910, 44.

CHARACTERISTICS OF TYPHOID FEVER OUTBREAKS.

BY H. N. PARKER.*

This paper is presented in the hope that it will help water works' superintendents to judge correctly whether their supplies are infected or not and to aid them in defending the reputation of water that is unjustly charged with being the cause of typhoid fever. To form an intelligent opinion on the matter the superintendent should make a record of the cases as they appear. In registration states this is easily done, but Illinois is not a registration state, and in many communities typhoid fever is not a reportable disease so that the information will have to be gleaned from conversations with the health officer, with physicians and from clippings taken from the local press. The best way to keep a graphical presentation of the typhoid situation is to spot the cases on a large town map as they appear. When this is done the map often shows clearly what factors are at work disseminating the disease.

Typhoid fever is not generated by sewer gas, rank growth of weeds, rotting vegetables in the cellar or by any such things. It is caused solely by the typhoid bacillus. The germs are liberated from the body principally in the feces and urine; so the determination of the causes and degree of prevalence of the fever in a community comes down to the study of the ways whereby these discharges may be passed from person to person.

Typhoid fever is often spoken of as a water borne disease. It is coming to be appreciated that this phase has led to undue importance being assigned to water as a carrier of typhoid fever; but it is with typhoid originating in this manner that members of this association are most familiar and so it is well to begin with it.

Water is not the natural home of typhoid fever germs; in fact, they do not live in it very long. Just how long they may survive is not known, but probably most of them perish in slightly polluted water within ten days and in heavily polluted water in even less time. Still

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a few of the typhoid germs are hardy and may persist much longer, perhaps a month or more. It is because these typhoid germs die out that water does not remain infected for very long periods and does not do much more harm. Continuous pollution by the excrement of typhoid patients is necessary to make a water supply a constant source of typhoid. This condition more usually obtains in surface water supplies than in those derived from the ground. Some cities use the unpurified water of rivers that at different times and in different places along their course receive the excrement of typhoid patients. If the amount of infective material is not great and it is considerably diluted in the river there will very likely be a few cases of typhoid in the city the year round. The spots on the map will be very much scattered and most of the patients will be users of city water. On the other hand, if the surface water is normally pure there will be long periods when there are very few cases amongst the consumers; but if a considerable amount of infective material is suddenly introduced into the water, as by a heavy rain washing in the contents of a typhoid infected privy vault, there will suddenly appear many cases amongst those who use the city supply. In both instances the characteristic feature of the map is that the spots are located in all parts of the town where city water is used. In parts having good private supplies there will be few spots.

There are many more communities in the United States that use ground water than use surface water and pure ground water supplies give the lowest typhoid death rates; but in time such supplies are outgrown and become inadequate and sometimes too they are likely to be defiled by the introduction of public improvements, particularly by sewerage systems. It very often happens that the first sewers put down are laid without cemented joints and any sewer line is apt to have some split pipes so that there is every opportunity for the sewage to leak away. Then there are sewers that are merely conduits blasted and hewn out of the rock. Such sewers, particularly in limestone regions, are apt to contain wide seams through which the sewage escapes. Thus along a sewer there is a very considerable chance for the sewage to find its way into private wells and in some instances into the public water supply. If the latter happens, sooner or later a general infection of the consumers will occur and the spots again will be widely scattered over the map. What usually happens is, that the private wells and rainwater cisterns along the sewer become infected and a row of spots indicates a line of polluted wells along the sewer. In towns where there is no public water supply and no sewerage system, conditions are different. In such places most families get water from wells. These are usually pure when first put down, but generally

people take little pains to keep them so. Privies, cess pools and sink drains are located close by without any thought of their effect on the water. So it often happens that the feces of typhoid patients find their way into a well and numerous cases result. If the use of the well is confined to the members of one family, one or more cases will appear in a single house, but if the well is a popular one and is used by several families for drinking water many in the neighborhood will have the disease. In either case, the spots on the map about the well will be close together; further away, they will spread apart, and at some distance away, will disappear. In other words, it is possible to use the well as a center and draw a circle of short radius that will circumscribe all the cases. The spots on the map will be localized and not dotted all over town as they are when the public supply is involved.

Another liquid in which typhoid fever is sometimes distributed is milk. It differs from other foods in that it is an excellent medium for bacteria; they thrive in it and the result is that even a slight infection of the milk is likely to produce widespread consequences. In milk epidemics the persons affected are very largely young people and children, and are almost entirely patrons of one dairyman. Therefore, the spots on the map will follow his wagon route. Where the route is a large one the distribution of the spots may be so general as to suggest that the water is infected, but by careful inquiry the two sorts of epidemics may be distinguished.

Another type of typhoid outbreak is that caused by the introduction into the community from outside of considerable quantities of infected food such as oysters or ice cream. These may be served at a church fair, a grange supper or some other social gathering and many may be given typhoid fever thereby. Such occurrences are somewhat unusual. The patients are likely to live in different parts of the town and so the spots on the map again will be considered separated; but by inquiry it may be developed that there is a social bond connecting the cases.

Sometimes when the typhoid cases are bunched in one part of town it will be found that there are many privies in the section, and if it is summer time it is likely that some of the latrines hold typhoid excrement and that it is being spread about by flies. This filthy animal seeks the vaults to feed and sometimes to place her eggs. Then with bedraggled legs and infected intestines she returns to the dinner table, where she walks over the food, the nipple of the baby's milk bottle, and drops her own excrement on many things; as a last act she may drown herself in the milk. Even in cold weather privies may be responsible for considerable typhoid fever, for they are often so filthy that it is impossible to use them without dirtying one's self. In that

case if the privy has been used by a typhoid patient the disease may be contracted there.

The spread of typhoid fever by contact is now recognized to be a very common mode of dissemination. It is known that the microbes begin to be discharged some ten (10) days or so before the patient commences to ail. Therefore it is apparent that in the operations of the toilet he may soil his fingers and afterwards in handling the pull chain, food and many other objects infect them. Others may handle these same things and thereby infect themselves. Thus, within a comparatively short time, there may appear within a single house, or perhaps a house and store, several cases of typhoid fever. Thus all the cases in town may be bunched in a few localities. When the map shows this to be so the superintendent should visit the premises harboring the contagion and by an investigation of the surroundings assure himself that it is really contact infection and not some other cause that is operative. This cause of typhoid fever is frequently unrecognized because it is only lately that typhoid fever has been generally admitted to be contagious, although Dr. William Budd as long ago as 1873 ably preached the doctrine.

The possibility of typhoid fever being disseminated in a community by typhoid carriers should ever be borne in mind. In recent years it has been found that a person who has recovered from typhoid fever may thereafter, for as long as 46 years, continue to elaborate typhoid germs even though he may feel perfectly well. Such persons are a menace to those with whom they come in contact and are particularly dangerous when they are employed where they have to handle food that is consumed raw. Indeed, several epidemics of typhoid fever on milk routes have been traced to patients that have had typhoid fever, made a good recovery, and later gone to work in the dairy business. So serious is this matter that in the future much blame will attach to any physician who releases a typhoid patient to work in a dairy, candy store, bakery, or in a similar place without first making sure that the patient is not liberating typhoid germs in his excrement and urine. On a spot map cases of typhoid caused by a carrier may be somewhat scattered or they may be close together. In any event their origin is likely to be somewhat obscure and the true cause will be detected only by those superintendents who know that carriers exist and use this knowledge in the attempt to trace out cases which appear unrelated and inexplicable.

These are some of the principal ways in which typhoid fever is circulated about a community. They are simple enough, and when they operate singly are comparatively easy to follow, but in large cities and sometimes in small ones two or three of the factors operate

together, and then the situation becomes confusing. In such cases it is always best to call in an expert.

This paper is not an attempt to make an epidemiologist of a superintendent, but it is designed to help him form a sound opinion as to whether his water supply is wholesome or not. In case the evidence points to its being all right he can be of considerable influence in the community in stilling alarm and inducing the public to take a sane attitude. On the other hand, if the facts seem to point to the water supply as the cause of typhoid fever the superintendent should call for assistance. He should not endeavor to make the public believe that an unsafe supply is a safe one. Every effort should be made to remove the polluting factors if it is possible to do so with the means at his command. If not, purification works should be installed, or a new water supply acquired.

DISCUSSION.

Smith: A peculiar outbreak of typhoid fever occurred in our city in the month of September. It was all in one particular district, which comes as near being what might be termed a slum as any we have in the city. Most of the people used water from a certain well which on examination was considered free from contamination. There was a total of 15 cases and the health officer investigated the matter very thoroughly. He came to the conclusion that the trouble was due to the fact that in the month of August a flood had occurred which covered the low lands along the river and flooded a field of sweet corn adjacent to this district. The people partook very freely of the corn, as it had been rejected by the canning company to whom it belonged. As soon as it was decided that the corn was the cause and its use forbidden the typhoid fever disappeared.

Spaulding: That last paper seemed to me to be worth the whole price of admission to membership in the Association. It is gratifying to have something that a water works superintendent can grasp hold of and use in his daily work. In Springfield our water supply is not above suspicion, and although the supply has been from underground sources for the last six months and it is generally found good by sanitary analysis, yet we have a rate of perhaps 13 to 20 deaths in 100,000. Every time I hear of a case of typhoid I feel uneasy for fear it might be due to the public water supply. In Springfield we have, perhaps, more than one-third of the city supplied from wells, and it has been found on numerous investigations (that is a number of wells have been analyzed), that most of the typhoid cases are traceable to

those bad wells. We also found this to be true. That a good many of the deaths reported were those which occurred at a hospital, the patient being brought from outside of the city. We have three hospitals, one a very large one. That would have a tendency to misrepresent the death rate in the city. If there is anyone here who can advise me as to the comparative death rate in rural districts with cities I would be very glad to know what it is.

Dr. Norbury: Epidemics of typhoid fever are very frequent in the rural districts. This is true in the mountain regions of the Allegheny mountains. In Illinois, in the rolling prairie lands as found in Morgan and Sangamon counties, quite a number of local epidemics have occurred in farm districts and the country school districts. We know there are other factors on the farm to be considered aside from the water supply, viz:—the care of vegetables, the use of fertilizing materials obtained from the cities, the presence of the fly as an agent in infecting milk, and the ever-to-be-thought-of "typhoid carrier", employed in the handling of milk used for dairy purposes.

I know of an epidemic in Philadelphia traced to the celery crop, coming from "the Neck" (that region in South Philadelphia between the Delaware and Schukill Rivers, where truck-growing exists).

Hansen: There is a tendency to overestimate water from private wells as a carrier of typhoid fever. There is no denying the general proposition that when water is once infected with typhoid germs it is a very potent factor in the spread of this disease, but I think that the private well is of comparatively minor consideration in connection with the perpetuation of typhoid fever as compared with other modes of transmission. Pollution from privy vaults and cess pools passing through the soil undergo a high degree of purification in a comparatively short distance, and though there is a serious danger in soil contamination, it is not nearly as great as was formerly supposed, at least in sparsely settled districts. Attention has been called to the use of dyes for detecting the passage of polluting matter towards wells, but it must be borne in mind that certain dyes will persist even though a high degree of bacterial and chemical purification has taken place. A very striking instance of this came to my attention in southwestern Ohio several years ago. In the town of Carthage the public water supply which is obtained from wells in a deep bed of gravelly material was frequently subject to tastes and odors characteristic of tarry wastes discharged into a depression of the surface of the ground at a roofing paper factory some thousand or more feet distant. These tastes and odors were at times so excessive as to render the water entirely unfit to drink, and yet all chemical and bacteriological analysis

carried out according to standard methods indicated the water to be of good quality.

As a rule the rural well receives its contamination from the top by the entrance of surface drainage or by the inevitable pollution that takes place where a bucket draw is used, but this contamination will not contain the specific germs of typhoid fever or any other disease unless the germs have been brought to the farm from elsewhere. In transmission of disease from one person to another on the same farm, it is much more sensible to first examine into the direct modes of infection, that is to say, by contact more or less intimate of one person with another, than to immediately inquire into the very roundabout way whereby contamination first reaches the privy, percolates through the ground to the well and then is brought back into the house again.

Dr. Park: I was very much impressed with this program and it was by accident that I received it, I missed two trains but finally got here tonight. I wish that every Health Commissioner in the State of Illinois could have been here and listened to these papers we have listened to tonight, and could take part in the discussion. I was especially impressed with what was mentioned about a water supply not being above suspicion. That impressed me for this reason—that I question very much if we have any cities whose supply is. The city of Rockford is supplied by artesian wells that were never open to suspicion. The Health Department in years past would take up samples for analysis simply as a matter of form, but it was not long ago we had over 200 cases of typhoid fever traced to the water supply. There were several interesting factors in that. One is that it started with severe gastro-intestinal trouble and was not over the whole city, but mostly in the southern and western part of the city, not very much of it reaching the northeastern part of the city. One of the sources of the trouble was found to originate from a well that was pumped for 10 hrs. and 15 mins. on Jan. 16th. (There was a factory fire the day before: the water supply was short.) That well was equipped with an air compressor, was expensive to operate and for that reason was only occasionally used. Through some defective arrangement in the equipment of the well the water had become contaminated. The well is about 1200 feet deep. I mention these things because some of you water works superintendents are going to be confronted with the same thing some of these days, and I mention what can happen to artesian water and how necessary it is to watch it, and I think that it teaches us all a lesson—that the city water supply and surface wells must be carefully watched. Upon reproducing conditions at the time of the fire it was found that seepage had gotten into the reservoir and pumping pit.

Hansen: Perhaps I left a wrong impression. It should not be implied that farm wells are not contaminated because as a matter of fact they often are, but it appears to me to be an error to assume immediately that if typhoid fever occurs it must be due to the water.

The average physician when he encounters typhoid fever in rural districts immediately wants all the water supplies in sight analyzed without making the least inquiry into other conditions. A physician's first care should be to inquire most circumstantially into the various ways in which the patient may have become ill by contact with others having the disease. When all possibilities of contact infection fail, then attention should be turned to foods eaten raw, water and infection by flies. Usually the last step in the inquiry should be the analytical examination of the well water.

THE DETAILED PROCEDURES TO BE FOLLOWED IN AN EPIDEMIOLOGICAL DETERMINATION OF THE ORIGIN OF A TYPHOID OUTBREAK.

BY H. W. HILL,* M. D., D. P. H.

The rapidity with which the routes of spread and source of a typhoid outbreak can be determined by modern epidemiologists and the practical infallibility of the results are incredible to those who have been accustomed to slow moving inquiries and investigations extending over weeks or months.

So drastically revolutionary are the achievements of modern epidemiological investigation that this incredulity is not unreasonable and can hardly be removed, except by a clear statement of the methods used.

The fact that the new epidemiological methods are the very converse of the old is in itself an explanation of their immense relative efficiency.

To make clear this complete inversion of the older methods an illustration may be offered.

Suppose a hunter is asked to find and kill a particular wolf whose depredations of the night before are indicated by bodies of dead sheep lying in a pasture. He may proceed in either of two ways to his task. He may gather an army of assistants and send them out to follow the outline of a thirty-mile circle, centering on the slaughtered sheep, with the hope of thus picking up trails of various wolves, intending then to work inward along each trail to determine if it be the trail of the guilty wolf, i.e. until satisfied that it does or does not lead to the dead sheep. Of course they might encounter the trail of the guilty wolf at once—but much more likely they would encounter many other wolf trails, each of which they would have to "run out", before at last they strike the right one. Indeed, they may not strike the right one at any time, because the one guilty wolf may have his range wholly within the circle the hunters are following—and in that case of course they could not cross his trail at all.

No real woodsman would follow such a plan. Rather he would go alone straight to the slaughtered sheep and work outward along the only trail that leads from them. That trail must be the trail of the guilty wolf and of that one only. It must lead directly to where

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that guilty wolf is now. Such a plan cannot fail to find not only *a* wolf, but *the* wolf, and once that wolf is found it can be put out of action forever.

The older investigators usually approached a typhoid outbreak on the lines of the first plan outlined above, arguing thus:

1st. Water is by all means the most likely route—we will therefore study the water supply or supplies, take samples, analyze them and in two, three or four weeks, decide whether or not we have evidence to show that the water supply or supplies or some one or more of them are or are not polluted.

2nd. Milk may be the route—we will therefore investigate the milk supplies of the community in detail, trace each to the original dairies or farms from which it comes, and since water is after all the chief route used by typhoid fever, we will investigate the water supplies of each dairy, taking samples and analysing them—a matter of two or three weeks.

3rd. Food is so ubiquitously used that it is almost hopeless to search for the route of infection there. However, we will look over the markets and stores, delve into the ice chests and inspect the back premises. If we find dirt and disorder, we can at least recommend that these be cleared up.

4th. Fingers and (in flytime) flies are ubiquitous. The physicians must guard against transfer by the former. If we find many flies, we must have manure piles and garbage taken up and removed because flies breed in them.

In brief, the older investigator's idea of a typhoid investigation consisted in flooding the community with inspectors of water, milk, markets, restaurants, dairies, back alleys and grocery stores; analysing, examining, probing the whole community from top to bottom, comparing notes, following clues, working especially in the slums—digging up engineering records, street department records, vital statistical records, interviewing physicians, talking to mass meetings of citizens—and usually coming away two or three weeks later with volumes of information and the epidemic still running. Whatever of field information was collected could not be interpreted fully until all reports and analyses were complete—and the mere bulk of the material was so great that the task of collation alone took precious time, to say nothing of getting out of it the essential facts. But the modern public health expert working alone or at most with one associate is ashamed to spend over three days in finding the channels of infection and their proximate source, and usually can announce indisputable and incontrovertible conclusions within twenty-four hours after he begins.

How is it possible that one man can find essential facts in twenty-

four hours by the new method that ten men often failed to find in as many days by the old? The writer has tried both methods, and the reasons are extremely clear.

There has appeared upon the scene a new figure—the public health detective. He is equipped with training, facilities, and experience for the ready clinical recognition of the numerous forms of infectious diseases, with their modifications and combinations; he is familiar with the wiles of the enemy which lead astray the amateur and the uninitiated; he has a trained nose for the trail; he has the ability to get the information he needs from the ignorant, the unintelligent, even the deceptive; and he, above all, is a specialist in his line, placing undiverted energies wholly upon his task. Finally, he has one simple guiding principle—that of going directly to the *known cases* and working the trails *outward from them.*

To illustrate the general principles, let us suppose notification be received that a typhoid fever outbreak exists in a far off community. The public health detective packs his grip and goes. He knows no details; he has never heard of this particular community before; he has not even any general information about the character of the country; he enters the community with no preconceived ideas. But he does know how typhoid fever originates and how it spreads. Water, milk, food, flies, and fingers are the routes—typhoid cases or typhoid carriers the sources. His duties are to find both; and to find them, not as a scientific amusement, or as a matter of record; not to furnish food for speculation—above all not to make a show of doing something—but *to stop the outbreak;* and then to advise measures to prevent recurrence.

The public health detective on entering the community affected by typhoid fever does not first examine the water supply, the milk supply, the sewage disposal system, the markets, the back alleys, the dairies or anything else. *He goes directly to the bedsides of the patients.* Of course he must obtain the names and addresses of the patients from someone—from the local health officer, if he has them; from the attending physicians, if the health officer has no list; from the lay citizens themselves, if no one else is immediately available. The more complete the list, the faster he can work, because then he is not compelled to hunt up the cases personally. But if there be no list, he begins making one himself. *His intention is to see just as many patients as he can,* for each furnishes evidence and he wants it all. But he knows that it is not always necessary at this stage to see absolutely all the patients, so long as he sees the majority.

Reaching the patient's* bedside, his investigation begins. Automatically, almost mechanically, he decides whether or not the patient has typhoid fever or not. Satisfied on that point, his first question is not, "Tell me all the different water supplies you have used, or all the sources of milk you have used." The first question is, "When did you first show the earliest symptoms of the disease?" Why? Because this date once fixed, the date at which infection entered the patient's mouth is fixed also, i.e. a date between one and three weeks previous to the date of earliest symptoms.† Remember that at this stage the detective may not have even an inkling as to which of the usual factors, water, milk, food, flies or fingers, is involved. Still less can he guess which particular water supply, milk supply, etc., of the many possible ones, may be the guilty one. But the answer to this question reduces possible routes *to those used by this patient*—not at anytime—but *during a specific period,* i.e. from one to three weeks preceding his date of earliest symptoms.

Not yet, however, are the milk and water questions offered. The second question is, "Where were you during that period?" Why? Because if the patient were not in the community during that period, he could not have contracted his infection within it, and does not belong to the outbreak under examination at all but to some other. He is, in brief, an "imported case" and while of course he is to be supervised lest he spread his infection to others, he cannot help to locate the source of the main outbreak—*unless perchance he be himself that source,* i.e. the introducer to the community of the original infection. If he be an imported case he is noted for further reference and the detective goes to another patient. If not, the questions continue. But not yet is water or milk or flies mentioned. The third question is "Were you associated during your period of infection with any then known typhoid case?" Why? Because such association, especially if intimate, makes it more than probable that the case under examination received his infection from the preceding case, rather than from any general route and that he is therefore a "secondary" case. If he had such associations, this is noted for further reference and the investigator passes on to another bedside. If not, the questions continue and now at last take up milk, water, food, etc., but of course only so far as to determine those used by the patient during *his infection period.*

*If the patient is a child or delirious or not strong enough for an interview, or speaks only some foreign tongue, the relatives, friends or associates must supply the information.

†The occasional exceptions do not affect the validity of this statement as a practical working rule.

Then the investigator passes to the next patient. What has he learned so far? Nothing much yet. But he has narrowed the possible routes of infection to certain water supplies, certain milk supplies, certain food supplies, etc., i.e. those used *by the first patient during a certain period,* and he has done this in thirty minutes—in scarcely the time it takes for the old style investigator to get his bottles ready to collect his first water sample!

At the bedside of the second patient, the same inquiries in the same order are made. If this second patient be an imported case, or a secondary case, he also is merely noted for future reference. If he be a primary, however, the origins of his drinking water, milk, food, etc., during his infection period are also ascertained. Perhaps he coincides with the first patient in every detail of alimentary supplies, in history and associations. If so, nothing much has been added to the detective's knowledge. But more than likely, dissimilarities have developed. Since the responsible water supply, milk supply, etc., must be one of those water supplies, milk supplies, etc., *used in common by primary cases* all those not common to both of these primary cases may be dropped from consideration (except in rare instances of multiple routes). Thus, if both have used the same water, water from that origin remains as a possibility. But if the water supplies have been different, *water is eliminated from the question entirely.* If the milk supplies are identical, milk remains as a possible route of infection; if not, *milk is eliminated from the question entirely.*

In brief, provided the information obtained be reliable, and it is a part of the public health detective's training to distinguish at a glance truth from falsehood, the honestly mistaken, or forgetful, or stupid replies from the reliable ones—and above all never to believe anything (to the extent of recording it) unless it is checked, confirmed and established as a fact, the modern investigator has in one hour narrowed his investigation to a point which the old style investigator often would not reach for weeks.

And so from patient to patient the inquiry proceeds. In the course of the day the investigator has seen perhaps thirty patients. The tabulation (probably already made in his own mind) shows, say, three imported cases, five secondaries, two uncertain or indefinite. The remaining primary cases show in common, say, one water supply only, the milk, etc., varying; or one milk supply only, the water, etc., varying; or no connection except attendance at some one social function.

Going straight to the route thus indicated, the public health detective quickly confirms the indications of his results. He *knows* that the route indicated must be the guilty one for *only* that route

can account for *all* the *cases*. He concentrates on that route until the evidence is complete—when and how that route became infected, when and by what sub-routes the infection was distributed, why it infected the patients found and not others, etc.

In this illustration I have assumed complete ignorance on the part of the epidemiologist as to everything connected with the community he is investigating, except what he finds by cross-examining the patients. As a matter of fact, every epidemiologist, however much a stranger to the particular community he enters, begins to learn about it from the moment he enters it.

Thus almost unconsciously he notes the size of the town and compares it with the number of cases reported as existing; if it is summer time he almost automatically notes the presence or absence of open toilets in the back yards, of manure piles and of garbage cans—all bearing upon fly infection. If it is winter time or the community be well sewered, he does not even consider flies. If the cases are grouped in one quarter of the town, while the public water supply extends all over it, he tentatively eliminates the water supply, before he asks a question. If good surface drainage and a sandy soil exist, or driven wells are chiefly in vogue, he tentatively eliminates well water—even before he registers at the hotel.

This is not and cannot be a complete synopsis of all the combinations of circumstances which the epidemiologist meets. It is intended to illustrate his methods and to show why they are incredibly rapid and incredibly accurate—how they eliminate speculation and guarantee a correct solution—which means of course the achievement of the great end, the finding of proper measures for suppression.

As soon as the route is indicated, he must *go to that route,* and establish beyond peradventure that it was in truth responsible. A water supply cannot convey typhoid if typhoid fever discharges have not entered it. There is no object in attributing an outbreak to fly infection from toilets into which typhoid feces have not been discharged at such a time as to account for the cases. A milk supply, not handled at some point by an infected person, nor adulterated at some time with infected extraneous matter cannot convey typhoid. Whatever his results, they cannot be true unless they are consistent—they should not be accepted unless they are provable—and proved.

If the public health detective is familiar with the community where the outbreak occurs, including its water supplies, its milk supplies, the sociological relationships of its people, etc., etc., he can often tentatively determine the cause of the outbreak by a mere inspection of the names and addresses of primary cases, especially if platted on

a map of the community, taking into account also the time of year, and other general points. But such deductions while often wonderfully reliable, can never be as conclusive and satisfactory as are the results of an investigation by even a total stranger, if the investigation be conducted as above described.

Once the main route of the typhoid outbreak is discovered, what should be done?

WATER SUPPLIES.—If the contaminating material can be excluded from the supply, this should of course be done instantly and hypochlorite should be added at once after cutting out the contaminating source. to secure disinfection of the water already in mains, reservoirs, etc., making sure, by blowing out dead ends, etc., that the hypochlorite reaches every part of the system. Thereafter nothing whatever is needed concerning the water supply, except to see that new contamination is not introduced.

If, as often happens, the contaminating material cannot at once be excluded from the supply, order the water boiled and begin at once the construction of a hypochlorite disinfecting plant. (The Minnesota State Board of Health maintains a portable plant, capable of treating at least 1,000,000 gallons of water per day. This plant costs less than $50 to build and set up ready for work. On detecting a water outbreak of typhoid or dysentery, the portable plant is shipped to the community affected and is usually in operation within twenty-four hours of receipt of notification of its need. In such cases orders to boil the water are superfluous; because the hypochlorite reaches effectively every part of the water system before the order reaches effectively one-tenth of the citizens. As soon as the hypochlorite treatment is installed measures for permanent reformation of the supply are begun. This may take weeks, months or years and the hypochlorite treatment in some cases must remain a permanent feature of the supply.

MILK SUPPLIES.—For milk outbreaks, the guilty supply should be cut off or pasteurized, unless and until the actual contaminator (milker with walking typhoid, milkman who is nursing a sick relative, carrier, etc.) is located and excluded from handling the supply. When this latter can be and is done, no further action is needed. Of course a thorough disinfection of all cans, bottles and other apparatus possibly contaminated should be done at once in all cases.

FLIES.—In fly outbreaks, immediate liming of all outdoor toilets, the prevention of soil pollution by the inhabitants, and the fly-proofing of toilets are the quickest and best methods for immediate results. The abolition of flies is a hopeful idea to pursue, but the exclusion of

existing flies from infected discharges is much more practical and almost infinitely quicker.

FOOD SUPPLIES.—Food outbreaks are usually due to one lot of infected food, long since eaten or otherwise disposed of and usually little can be done about it. When, however, the food (as in the case of milk) was infected by a handler, who may still be handling new supplies, the handler should be located, if possible. Otherwise the particular article involved should be excluded or used only after cooking.

FINGERS.—Finger outbreaks can be handled only by supervision of existing infected persons, their nurses and associates.

Every typhoid outbreak becomes a finger outbreak at some stage or other, whatever its original cause, i.e. the primary cases can be prevented by cutting off contamination from the main conveyor (water, milk, flies, etc.); but secondary cases can be prevented only by immediate attention to *every* existing infected person.

Hence *every* typhoid outbreak should result in the immediate appointment of a visiting nurse or equivalent officer, whose sole duty it is to visit every day the existing and new cases, instructing the attendants in the care of discharges, the care of their own hands, etc., the prevention of sale of food, milk, etc., by infected persons or from infected houses, etc. In addition the epidemiological search for missed cases and carriers should be continued as long as new known cases continue to develop. This most important second stage in the control of an epidemic does not call for description here. Like the finding of the origin of the primary outbreak, the finding of missed cases and carriers is based upon detective principles, and depends primarily upon the epidemiologist.

Finally, publicity is needed. Publish abroad the cause of the main outbreak, and warn everyone of the dangers of the secondary infection from existing cases. Too often both public and official opinion consider the danger over when the guilty water is purified, the guilty milk shut out, etc. As a matter of fact cases from the original cause will develop for a period of three weeks after the main route has been abolished (due to typhoid bacilli ingested from the main route before it was purified). Further, each primary case is likely to give rise to secondaries. Hence *every case, primary or secondary, whenever developing,* is a separate focus of the disease for spread by contact—chiefly fingers, and every typhoid epidemic must be supervised for three months at least, often longer, before typhoid fever is abolished from the community.

The following card has been found useful in Minnesota for securing data from typhoid patients.

EPIDEMIOLOGICAL REPORT ON A CASE OF TYPHOID FEVER

NAME IN FULL ________ SEX ____ AGE ____

PRESENT ADDRESS OF PATIENT ________ *CITY / VILLAGE / TOWNSHIP ________

(IN A CITY OR VILLAGE GIVE STREET AND HOUSE NUMBER. NAME OF HOSPITAL, ETC.; IN A TOWNSHIP GIVE NAME AND LOCATION OF FARM, CAMP, MINE, ETC.)

DATE OF BEGINNING RESIDENCE AT PRESENT ADDRESS; MONTH ________ DAY ____ 19 ____

PRESENT STATUS OF CASE (RECOVERED; CONVALESCING; STILL SICK; DEAD*) ________

PRESENT ATTENDING PHYSICIAN ________

(NAME AND ADDRESS)

DATE OF EARLIEST SYMPTOMS (PLEASE DETERMINE ACCURATELY) MONTH ________ DAY ____ 19 ____

NOTE—THE DATE OF INFECTION AVERAGES TWO WEEKS PREVIOUS TO THIS DATE

FIRST SEEN BY PHYSICIAN; MONTH ________ DAY ____ 19 ____

NAME AND ADDRESS OF THIS PHYSICIAN ________

SIGNED: DR. ________ OF ________ MINN. ________ 19 ____

*STRIKE OUT WORDS WHICH DO NOT APPLY (OVER) DATE

PATIENT'S OCCUPATION DURING THREE WEEKS BEFORE THE EARLIEST SYMPTOMS OF TYPHOID APPEARED?

(ALSO GIVE NAME OF EMPLOYER AND ADDRESS OF HOUSE, OFFICE, MINE, FACTORY, ETC., WHERE PATIENT WORKED DURING THESE THREE WEEKS)

WHERE WAS PATIENT LIVING?

(NAME EVERY EATING AND ROOMING PLACE WITH DATES FOR EACH PLACE DURING THE THREE WEEKS BEFORE EARLIEST SYMPTOMS DEVELOPED)

MILK USED BY PATIENT?

(NAME AND ADDRESS OF MILKMEN SUPPLYING PATIENT DURING THE THREE WEEKS BEFORE EARLIEST SYMPTOMS DEVELOPED)

WATER USED BY PATIENT?

(NAME AND LOCATION OF STREAM, LAKE, WELL, OR OTHER SUPPLY DURING THE THREE WEEKS BEFORE EARLIEST SYMPTOMS DEVELOPED)

WAS PATIENT ASSOCIATED DURING THESE THREE WEEKS WITH ANYONE PREVIOUSLY SICK WITH TYPHOID FEVER? IF SO GIVE DETAILS

(DATE OF ASSOCIATION; NAME AND PRESENT ADDRESS OF SUCH ASSOCIATE. STATE RELATION TO PATIENT, AS FATHER, MOTHER, SISTER, BROTHER, FELLOW-BOARDER, ETC.)

SINCE THE DATE OF PATIENT'S INFECTION HAS ANY ASSOCIATE DEVELOPED TYPHOID SYMPTOMS?

(NAME AND ADDRESS OF ALL SUCH CASES)

PHYSICIAN'S VIEW OF SOURCE OF INFECTION?

(FINGERS; FLIES; FOOD; MILK; WATER; ETC.)

HAS ANY OTHER RECENT CASE BEEN TRACED TO SAME SOURCE?

(NAME AND ADDRESS OF SUCH CASE OR CASES)

DISCUSSION.

Monfort: In considering this excellent paper and others upon typhoid fever given last night, it seems to me that as water supply people such an investigation should never be called for. It is not enough to fill a map full of tacks, so that the burden of proof rests on other sources of infection, namely, food, fingers, flies, etc., but it seems to me that the point for us should be to lock the door first upon a suspicious water supply and not wait until the harm is done. Daily bacterial study of the water supply from surface sources, and intensive studies of deep waters at somewhat longer periods are matters of prime necessity if consumers are to be safeguarded. Determinations once a week or once a month, from samples shipped some distance are of little weight as compared with those made on the spot with fresh samples. Where such procedure is followed Dr. Hill's necessary work is very much simplified.

Gwinn: It is a very interesting paper. I should think it would have been still more valuable to the members if the Doctor had included a list of the questions to be asked the patients and in making his examination of various cases. That is, to provide a form in regular order which could be used by those who are investigating cases in isolated communities . I believe this would be a very valuable addition to the paper. (Note:—Card was afterwards supplied by Dr Hill.)

*Rickards:** Dr. Hill has indicated in his paper the general order and trend of questions to be asked in investigating the cause of an epidemic of typhoid. It might well happen that the particular circumstances surrounding some one epidemic might render it advisable to change the order and phraseology of the questions asked, but for general use by water works superintendents a series of standard questions might be of considerable advantage. Such a form will not be difficult to prepare and might serve to stimulate superintendents to make a more thorough investigation as to the probable source of infection when typhoid cases become numerous in their vicinity. In times of emergency, when circumstances point to water as the cause of the infection you have a trained man, Dr. Bartow, who can be called upon to investigate, while the department with which I am connected, Municipal and Sanitary Dairying, stands ready to investigate if milk appears to be the vehicle by which the infection is carried.

*Asst. Prof. Municipal and Sanitary Dairying, Univ. of Ill.

ANCHOR ICE.

BY LINDEN C. TROW.*

FELLOW SUFFERERS:—When a period of about six months has elapsed after a young man has paid his first ten dollars on a correspondence course in Hydraulic Engineering, and has secured a position with some water company, he signs his name "John Smith, Hydraulic Engineer", spelling the last two words out in full; but after having had some fifteen to fifty years of experience along these lines, he signs himself just plain John Smith, his eyes having been opened to so great an extent to what this field of engineering covers that he doesn't feel as though the ownership of the term is his sole property. Two years ago, I sent word to this Association that I would deliver a paper upon the subject of Anchor Ice, but at the present meeting I would rather simply ask the question, "What is Anchor Ice?"

The severe winters in the region of the Great Lakes have always affected the water supply to so great an extent that it has become a custom to couple the ice question with problems relating to an adequate water supply.

Of course a shut down of one minute is an unpardonable occurance in the eyes of the consumer, and keeping this point in mind, consider the effect of a five-hour shut down and a shortage of water at breakfast time.

In different countries, ice which causes a stoppage in the intake is known by different names. In Scotland it is called Ground Gru and Lappered Ice; the French Canadians call it Moutonne from its resemblance, after accumulation, to the wool on the back of a sheep; others call it Spicular Ice; but the name of Frazil, given by Mr. Murphy in his report to the Royal Society of Canada, is the one most generally used along the northern lakes. Anchor Ice is the common expression in the United States. Although it is in reality misnamed, it is such a handy phrase that it will probably remain in spite of any efforts to credit Frazil with the record it has made. Were you to tell a consumer that you had Frazil, when he wanted to know why he couldn't

*Chief Engineer Water Co., Lake Forest.

get water, he would probably think you had been partaking too freely of some new breakfast food.

It is doubtless well, at this point, to state that men who have made a thorough study of ice formation, divide the ice into three classes; first, sheet ice formed upon the surface; second, anchor ice, formed upon the bottom; and Frazil or ice formed below the surface and above the bottom. Anchor Ice and Frazil are both formed only when there is open water above. Along the west shore of the lake there are a few features which are always present when such ice is formed; the wind must be in a westerly direction and the thermometer must be below freezing. Frazil or Anchor Ice are never formed when the sun is shining or when there is a cloudy sky at night; and the rising sun always heralds the fact that the accumulation of ice has ceased. The very slightest rise in water temperature relieves the situation and the ice will loosen it's grip if the water is warmed to the thousandth part of one degree on the positive side of freezing.

Anchor Ice is formed upon the bottom of rivers or bodies of water where the water is in motion; the growth of Frazil is in the water itself and the necessity for the presence of some object for it to attach itself to is eliminated, as the floating particles will adhere one to another. The growth of Frazil must be accompanied by surface cooling through wind, or rapid agitation, and by radiation.

In questioning men of practical experience, it is very interesting to note the different theory which each advances as to the cause of the ice which closes an intake, and the theory of one man will possibly be an absurdity in the eyes of the next man. One engineer advanced the following: "It is a law of nature that warm water must rise, also a law of nature that objects lighter than water must rise, hence it stands to reason that water at the bottom of the lake is the coldest and that is the point where the ice is formed and, from where, having become lighter by the process of freezing, it floats to the surface unless drawn aside by some disturbance in the water such as an intake, whose suction causes the ice to adhere to the screen in the form of minute crystals, until the screen is so thoroughly covered as to stop the passage of water." This theory is only handicapped by the fact that the rapid circulation of water ceases when the thermometer reaches 39 degrees F.

Another is this: "In 1836, Gay-Lusac observed, that water, when placed in a vessel and covered with oil, may be cooled to 10 degrees F., without freezing; but if the vessel is shaken, solidification ensues at once. During a west wind the water at the surface is always warmer than the water at the bottom, and this warm water upon any surface may act as a blanket in some such manner as the oil, and the water

beneath reach a point below freezing until disturbed by coming in contact with the intake."

In one city north of Chicago, I found a 42" intake with thirteen openings, some pointing up, some pointing down, and others pointing at different angles; for there is a theory that the way which the opening looks makes considerable difference. Some of the openings are covered with iron screens and some with wooden screens, but in spite of all these precautions, this city's intake was closed by ice this winter to such an extent as to make it necessary for them to send a diver down to make an opening. Some one connected with the welfare of that city conceived the novel idea of placing a fan over an opening in the intake to be propelled by compressed air, which would keep away the ice. The engineer and Commissioner of Public Works spent a few peaceful nights in sleep after this installation was made, but one night the water ceased to come. The diver was hurried to the scene and lowered to the bottom to discover what had gone wrong with the fan, and there over the intake he found it churning away completely housed for the winter in a dome of ice.

Of the theories advanced by practical men, or the man at the throttle, many will be seen to be very near to the truth of the situation; but it still remains for such institutions as our State Universities and other organizations of research to get at the whole truth of the matter.

The usual method of procedure in a case of "Anchor Ice" is for the night engineer to call the Superintendent out of bed about 12 o'clock to tell him "There is a valve out of the pump". When asked over the 'phone "Which end?" his confused reply is "There seems to be one out at each end, both sides". Crawling into his clothes, the Superintendent proceeds to the pump room to find the hand of the vacuum guage peacefully reposing upon the pin.

To remedy the difficulty the valves in the well are closed and any pressure which may be left in the mains is thrown upon the intake through the by-pass. At times, we have been able to maintain a pressure of seventy-five pounds upon the intake for fifteen or twenty minutes before there would be any noticeable release. About one out of five times, this method when tried before sunrise has proved satisfactory, the other four times, more water was lost back flushing than came back before the ice again closed the opening. The pumps usually get a full supply of water with the aid of nature's remedy, the heat of the sun, about as soon as the plant that labors with back-flushing and other contrivances.

This paper with so many questions left open is not presented with an idea of explaining the difficulties so minutely that they may be

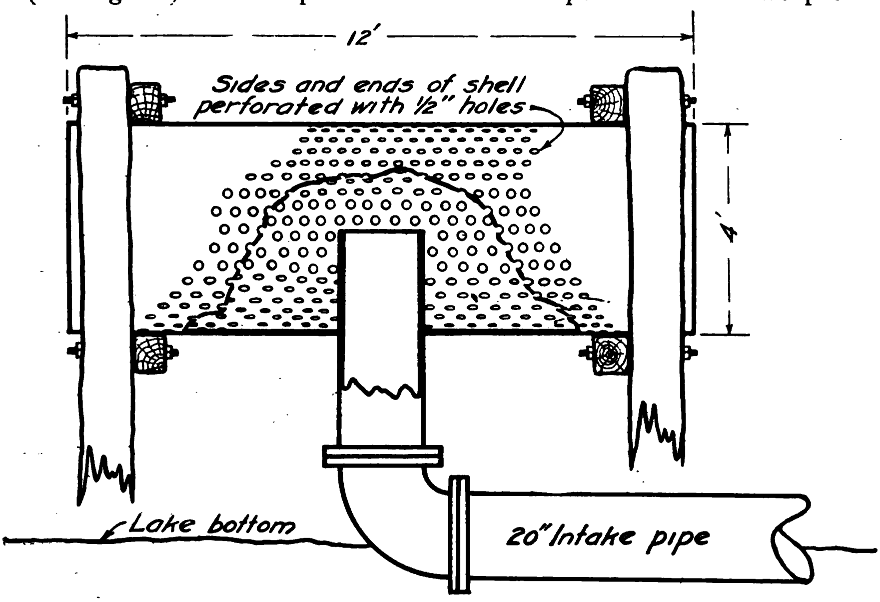
entirely overcome, but that inquiry and research may be made along this line which may lead to the ultimate elimination of the trouble.

DISCUSSION.

Hansen: Mr. Keeler solved the difficulty at Rogers Park; I think we should have him tell us about it.

Orvis: We have problems of this kind. Anything that can be done, ought to be done to solve it.

Keeler: I can give you the solution we arrived at. We have operated the station for about 22 years, and outside of not to exceed three minutes were not troubled with anchor ice. The way we solved the problem was in the design of our intake strainer at the outer end of out intake. I will illustrate on the blackboard the design of our intake. (See figure.) The important and essential point was that we pro-



INTAKE CRIB AT ROGERS PARK

Fig. Prevention of Anchor Ice at Rogers Park.

jected the end of the pipe up about 18 inches above the bottom of the cylinder. This cylinder is 4 feet in diameter and 12 feet long, perforated on all sides, top, bottom and end with half inch holes. Size of pipe 20 inches. The secret of the success of this design, as I

figured it out, was the fact that the only place we had where any ice could get in was the 20 inch opening of the pipe. This has worked successfully for 22 years.

Orvis: What quantity of water do you use?

Keeler: Three million gallons a day. Depth of water 26 feet. Cylinder was placed about four feet from bottom of lake and secured by timber to piles driven in bottom.

Gwinn: What were the size of the perforations.

Keeler: One-half inch.

DeBerard: How close together are the partitions?

Keeler: Not over one inch.

Orvis: I would like an estimate of the cost.

Keeler: Not very expensive. I cannot give you the exact cost installed.

Trow: We have overcome it in another way by having two intakes. One of these intakes is closed about 6 o'clock p. m., when an unusually cold evening follows a day of sunshine, and then if the ice clogs the open intake, between midnight and morning, we are able to get water through the other until the sun rises and the formation of ice below the surface ceases.

Parkin: Did I understand you to say that ice is not formed when the sun shines?

Trow: Yes. No ice is formed below the surface while the sun shines nor on a night following a cloudy day.

Parkin: Could you not fool it by using an electric light?

Mr DeBerard: Anchor ice at the two-mile crib, Chicago, has been handled successfully this year by the use of compressed air, which is shot into the ports and frees the ice adhering to the sides, which are of wood about 4 feet square. A "limber" chain with crosses on it passes through each port with the ends on top. By pulling on the chain the men determine the extent of ice formation. Compressed air is delivered at the outer end and at the middle of the port. The dislodged ice is scooped up from the area within the crib before it has a chance to enter the tunnel inlet pipe. Formerly water under pressure was used, but Mr. McDonough tells me the air is so successful that in designing future cribs they will undoubtedly include permanent installations for its use.

Langdon Pearse (by letter): I was very glad to read Mr. Trow's paper on anchor ice and see what he had to say. The subject is one of great interest to water-works and power men in the North. At our 39th St. Pumping Station we have troubles with anchor ice, owing to

the shallow water in which the intake is located, some 12 feet deep. The high velocity through the intake draws in floating ice as well, which stops our racks. One of the difficulties along the lake shore seems to be the accumulation of ice driven in by the wind and shattered against the shore so that probably much of the ice that reaches the intake at 39th St. Pumping Station is not properly anchor ice or frazil ice, but broken particles of surface ice which are sucked in by the current. The stoppage sometimes lasts for 3 or 4 weeks in the winter time. As this water is used for flushing purposes only, the restricted flow is not so serious, as for a water works intake.

In Maine many of the cotton mills have long canals between the inlet from the mill-pond and the wheels. A floating framework of planks is frequently used in the winter time to hold an ice sheet over the entire water surface of the head canal. This probably prevents the formation of anchor ice or frazil ice as indicated.

The best collection of information on the general question of ice formation, and the remedies tried, is a book entitled "Ice Formation" by Prof. H. T. Barnes, of McGill University, who has summarized very accurately the conditions requisite for the formation of ice and the remedies. As many of the members of the Illinois Water Supply Association may not be familiar with this work, I will briefly summarize some of the remedies which have been tried and found successful. In the first place, as I have mentioned before, if ice can be held around an intake, or the head canal, for sufficient area, the formation of frazil or anchor ice can be prevented. In the second place, if the racks are heated, the formation of ice on the racks can be prevented. A small amount of heat applied to the upper end of iron rack bars is very efficacious. Several lines of steam pipes laid along the rack bars above water and covered with insulation of tar-paper and tongue-and-groove flooring have proven effective. In other cases, the racks have been removed altogether, and the ice allowed to pass through the turbines, the temperature of the turbine room being kept high enough to prevent the formation of ice on the inner wall of the shell. Again, steam may be injected into the turbine casing, and thus the shell may be kept warm enough to prevent ice from attaching itself. Only occasional injections are necessary. It is on record, in some cases, where no protection has been provided, that the turbines have filled up solid with ice.

As regards the application to the water-works intakes along Lake Michigan, where an intake crib is built, there would seem to be little difficulty in maintaining clear racks where the inlet screens can be housed over, and a moderate amount of heat applied to the rack bars. For the small water-works intake, with simply an inlet

strainer under water, protection would seem to be very difficult, unless ice can be held over the top of the intake, which, in the case of a large lake, like Lake Michigan, is extremely difficult, the force of the wind driving the ice sheet before it and making open water; or, on the other hand, crushing the ice with great force against the shore. The remedy suggested by Mr. Trow, of reversing the flow, seems to be very practical, and in exceptional cases, might be increased in effectiveness by heating the water used, either by steam or electrical power. Judging by the investigations of Prof. Barnes, a small amount of heat is very effective, if properly applied.

THE PURCHASE OF COAL ON SPECIFICATIONS.

BY WARD O. COLLINS.*

I have assumed, in the preparation of this paper, that many of the members of this organization are more or less directly interested in the purchase of and use of coal.

While many of you have had no practical experience with the so-called B.T.U. system, I assume that many of you have heard something of this basis of purchasing; and perhaps many more of you thoroughly understand the practical requirements of coal and the difficulties of obtaining a uniform supply.

I realize that there are members of your organization who have had a great deal to do with the working out of the system and apparatus by means of which our work has been able to start and progress.

The results and deductions recorded are based on my own personal experience in the practical working of various methods of purchasing coal. My experience started several years before the B.T.U. method was ever heard of, during the days when the boiler evaporation method of testing coal flourished. I clung to this method until thoroughly convinced that the B.T.U. system was the more practical and cheaper to handle.

I make no claim for originating the fundamental system and in fact freely state that we have always been glad and quick to adopt the best experience of others, wherever such experience was borne out by the facts as we found them.

Considering the wide use of coal, the vast amount of money involved in the industry and the many and wide variations in the quality and characteristics of coal, it seems strange when we stop to consider it, that the purchase of this material along modern lines has been so slow in starting and developing.

However, the heat value and burning qualities have always been the underlying basis of consideration, wherever it has been possible to choose between one or more grades or sizes of coal. We find all sorts of crude methods used in making these decisions and too often

*Vice-President Gulick-Henderson Co., Chicago, Pittsburg, New York.

we find that a consumer simply knows that one kind of coal seems to burn better than another, without really knowing whether or not it is cheaper for him, than some other available fuel.

Until a few years ago the larger consumers employed the boiler test to determine whether or not coal was efficient or up to contract requirements. Selections of coal for contracts were frequently made by this method. Coal contractors were requested to make a shipment of coal representative of the fuel which they proposed to furnish if awarded the contract. Several shipments so received were subjected to burning tests under the boiler and the evaporation per pound of coal and the cost to evaporate 1000 pounds of water were determined with greater or less accuracy, depending on the care with which the tests were made.

If a coal contractor was wise, as they usually were, extra good coal was often supplied for the test and generally extraordinarily high results were recorded.

In individual cases, however, this method has been satisfactorily handled and the system is often useful in determining the general grade of fuel best suited for any particular boiler equipment.

On public and political contracts the evaporation method has caused no end of criticism, as there are many conditions under the control of the testing engineer and firemen by means of which the results can be controlled at will. Furthermore, even if the tests are honestly and efficiently made, they are useless in the case of a legal fight; as it is always possible to show that the conditions of testing are constantly changing to a greater or less extent due to the formation of boiler scale, weather, load and firing requirements.

Along with and following this method of specifying and regulating deliveries, a chemical analysis, showing the amount of moisture, volatile matter, fixed carbon, ash and heat value, was frequently incorporated in the contract together with the guarantee of evaporation obtained by the boiler test method. This was often a strengthening clause and was many times the basis of making settlement, where substitution was clearly evident.

It cannot be said that any of these methods were ever universal to any extent, nor is the new and improved B.T.U. system in universal use; for in many cases the fuel which forms from 10 to 25% of the yearly expense, is bought without any supervision whatever, while the much less expensive items such as steel, pig iron, cement, electrical materials, paper, etc., are often purchased on the most rigid specifications and guarantee.

Following the public demand for efficiency and honest purchasing, the political and public institutions have in many cases been the

leaders in scientific methods of purchasing coal. Thus in 1907 the U. S. Government adopted a form of B.T.U. specifications, which is now in use by practically all Government departments. The methods used by the Government and the method now in use by other consumers are, generally, based on the same fundamental principle, which is the "delivery of heat units." While there are several different methods of regulating and figuring the value of a delivery, practically all of them consider the analysis of as much importance as the weight of the coal.

Our concern is now setting the price on $1,500,000 worth of coal delivered annually to at least 400 consuming plants. Among them are all of the Cook County institutions, stations of the Sanitary District of Chicago, power and heating plants of the South Park Commissioners and the West Chicago Park Commissioners, all schools under the Board of Education, as well as many private plants, loop buildings and power plants in smaller cities.

Our recent work for the Merriam Commission, investigating the various purchases in the City of Chicago, was beneficial in showing the abuses which often gradually grow out of the old or slack methods of purchasing.

The result was that the men in actual charge of these purchases welcomed an opportunity to purchase their coal supply on a specification and under a system which would not only give them good coal at a low figure, but also relieve them of the responsibility of the criticism due to the continued and expensive abuses under the old and more common system. Since the adoption of the Merriam Commission recommendation in this respect, the Public Works Department of the City of Chicago is getting a better grade of coal and saving hundreds of thousands of dollars by the elimination of unbusinesslike methods; so that today nothing but commendation is heard from even the coal trade itself in connection with this big item of expenditure.

The B.T.U. system as applied to public institutions briefly is as follows: bids for the delivery of fuel are advertised for in the usual way. The advertisement differs little from the common form and often simply states that an amount of coal is desired and that the same will be purchased in accordance with the B.T.U. system, specifications for which may be had by application, etc., etc.

The specifications as we prepare them differ in detail for different institutions, due to the variations in the coal requirements and business methods of the office. All embrace clauses to cover the following principal points; and it will be seen that a specification should cover something more than the mere physical properties of coal.

First.—Conditions under which proposals are to be made must

be clearly defined, the bond, certified check, and other general conditions must be explained.

Second.—Special requirements, such as time and place of delivery, amount of coal required, strike clause (if any), liability of contractor and clauses covering the purchase on open market, must be clearly and specifically drawn. Since a specification is usually the basis of and a part of a contract, it must be legally drawn and fair to both the contractor and consumer, as an unfair contract may not stand the test of the court, even though it may have been accepted by the contractor.

Third.—A general description of the coal wanted should be included in the specifications. This description is usually composed of the chemical analysis limits, together with a paragraph relating to size, as follows:

DESCRIPTION OF COAL WANTED.

> BITUMINOUS LUMP containing not less than 12500 B.T.U. per pound of dry coal and not to exceed 14% of ash dry coal. Lump Coal shall contain all the lumps as mined and shall be so screened as not to contain to exceed 20% by weight of coal which will pass through a 1¼″ circular perforated screen.

These limitations are the basis on which future deliveries are to be enforced. Similar chemical and physical restriction can be drawn to cover other grades and sizes of coal, such as screenings, chestnut anthracite, washed and unwashed nut, etc.

Fourth.—A specification must contain a clause covering and providing for a means of rejection of a shipment should it be far below the limits of the specification as to quality and size.

If coal inferior as to size and quality is kept and burned, it may be accepted and paid for on the basis of deductions made in accordance with the terms of the specifications.

The penalty for excess of fine coal is usually based on a deduction of something like 1½% of the contract price for each 1% excess of fine material as limited above.

For example, if lump coal containing not to exceed 20% fines, at about $2.00 per ton was contracted for and mine run coal containing 32% of fines was actually delivered, the deductions due to fineness would be 1½% of $2.00 for each 1% of fine coal in excess of the 20% of allowed, or a net deduction of 36 cents per ton. This deduction would be made in addition to any deduction originating from lower heating value.

Fifth.—The real essence of the specification lies in the clause

covering methods of payment. This paragraph must literally be bull strong and hog tight.

Believing that each individual contractor should know the analysis and heating value of the coal he is attempting to sell, the responsibility of stating the exact guarantee as to moisture, ash and heat value, is placed upon him. A sheet is provided whereupon he may place his detailed information together with the price per ton and the number of heat units which he is willing to guarantee to furnish for one cent.

The testing and payment clause clearly states in words how the B.T.U. for one cent shall be figured, and is briefly stated as follows:

Multiply the number of heat units per POUND OF COAL AS DELIVERED by two thousand. This gives the number of heat units delivered in every ton. Divide this product by the price of the coal per ton expressed in cents plus an arbitrary correction for ash amounting to one-half the percentage of ash expressed as cents.

Since the analysis of coal is often expressed on the dry basis, the heat value as delivered must be determined by deducting for the percentage of moisture. Thus the calculation resolves itself to this formula:

$$\frac{\text{B.T.U. DRY COAL} \times \text{\% DRY COAL (100 \% less \% of moisture)} \times 2000}{\text{PRICE PER TON IN CENTS} + (0.5 \times \text{\% of Ash Dry Coal})}$$

The result of this simple calculation gives the number of heat units for one cent which the bidder proposes to deliver.

Samples are taken from all subsequent deliveries and of these samples analyses are made and by a converse-calculation the value of the coal as delivered is accurately determined.

The specifications state the high and low limits of analysis which will be accepted under any conditions. Coal accepted is paid for on the showing of the analysis.

The method of sampling, chemical analysis and other details of the process are now fairly well standardized and while there are still differences of opinions in minor details, nevertheless it is a fact that they are as well standardized and can be as accurately handled as in the sampling and testing of other materials of commerce, such as iron, steel, cement, etc.

After the preparation and adoption of a scientific and fair specification, the personal element again enters and unless the work is honestly and accurately done, without fear and without favor, the system becomes a failure. Although the system has enjoyed a steady growth, still much of the criticism and many of the objections are based entirely on the inefficiency and dishonesty of the testers.

The best of apparatus and the most careful and straightforward work are required. Needless to say the tester must have no affiliations or connections with the coal trade and his efforts must be to maintain the absolute confidence of the coal trade as well as the consumer.

We have among our contracts several cases where the contractors have continually earned a bonus due to their care in the selection of good coal. There are other cases where they always run behind, due to over bidding their coal either through accident or intent. We believe that the bonus should be paid where it is earned and, likewise, believe in making deductions where the coal is below the guarantee.

The B.T.U. system has many advantages especially for public bodies and large purchasers where outside influences are liable to interfere.

First.—Bidders are all placed on exactly the same basis for consideration. Since awards should be made on the basis of the maximum number of heat units for one cent, there can be no possible controversy if this rule is followed. For example bids are received from three different bidders on Illinois or Indiana lump. No. 1 bidder agrees to furnish "Atlas Lump" on the basis of 75000 B.T.U. for one cent. No. 2 agrees to furnish "Perfection Lump" with 100,000 B.T.U. for one cent, while No. 3 agrees to furnish "Economy Lump" with a guarantee of 125,000 B.T.U. for one cent. At a glance a child could tell which is the cheapest and best bid. Under the old method the bidder offering "Perfection Lump" would have a big advantage, especially if he were politically backed up, as even any ordinary "tax payer" would be expected to know that "Perfection" was better than either of the other two names.

Second.—Since only price and quality enter into the calculations upon which awards are made, it will be evident that "trade names" have no influence whatever. Thus it is often possible for dealers to offer coal of good quality from small and comparatively unknown mines and, if the bidder is responsible, such bids can be accepted without any possible chance of loss.

Third.—The consumer is insured against the delivery of poor coal, since the penalties tend to stimulate the delivery of only the best coal to those plants where regular tests are made.

Fourth.—A specific and equitable basis of payment is provided for, should coal be below grade. Coal rejected under the old methods of contracting was often accepted at contract price and burned up simply because of the delay in getting it removed.

Fifth.—A definite basis for cancellation of contract and otherwise regulating of deliveries, etc., is provided.

Sixth.—Constant testing and inspection has a healthful influence on the plant. By means of the results, operating engineers are enabled to get better efficiency from their men. Furthermore, the knowledge that constant and regular testing is being done stimulates the best efforts of the contractor to furnish uniform coal.

Seventh.—The system can be cheaply and efficiently applied at a cost well within the limits for inspection and testing, seldom exceeding one to two cents per ton.

Of course, it may be truly said that the coal trade as a whole opposes the system. Some of the dealers oppose it because it eliminates their chances for the substitution and delivery of poor coal. Other operators producing low coal naturally are at a disadvantage and also use their powerful influences to return to the old hit and miss methods. Few of them stop to consider how it has really opened up the field for fair and equal competition, especially in public business. In general, however, all this opposition is and has been a boost, for it is plain to be seen that their opposition is based on reasons of personal gain and if they really favored the system too strongly the purchasers would not want it.

With all of the opposition from this source, however, there are always plenty of bidders. Generally there are more bids received than ever before, when bids were taken under the old methods.

The Board of Education of Chicago formerly received only three or four bids, and some of these were from affiliated companies. Last year there were twenty-nine (29) bidders, all independent and actually after contracts. The South Park Commissioners received ten bids for a much smaller amount of coal; and the West Chicago Park Commissioners, using still less coal, received fourteen bids.

It is often said as an argument against the adoption of the system, that the prices will be raised to cover the element of gambling, due to possible variations in the coal. This most certainly has not been the result as far as we have been able to observe. In fact, the price per ton has usually been lower for the same grade of coal than when the old style method of purchasing was employed. The increased competition governs this to a large extent.

The B.T.U. system gives the contractor a means of discrimination by means of which the large consumers always profit. By this I mean that the bidders are usually ready to sell coal in large quantities cheaper than they would be willing to sell the same coal to smaller consumers. Thus he may expect to get $2.55 per ton for coal from the small consumer and be willing to accept $2.50 from the big consumer directly across the street. So he simply overbids the coal to the big consumer, buying on the B.T.U. basis, and takes a deduction of

five cents per ton; and the small consumer never knows that he is paying more than his larger neighbor.

The savings by the installation of this system in the Board of Education of Chicago have been figured to exceed $100,000.00. The greater part of this saving is due to the increased competition and consequently lower prices due to the assurances of fair treatment afforded by the method. A part is due to the penalties deducted for the delivery of inferior coal and no account is taken of the large unknown saving by the use of the better grade of coal received.

Similarly, great savings are being made in other public and private plants.

Therefore, judging from the continual growth of our own part of this work and since we constantly hear of the success of others and of new large consumers starting to take bids on this or a similar basis, I feel safe in predicting a gradual and steady growth and improvement in the system.

DISCUSSION.

Chairman: The subject of coal is of vital interest to all of us.

Cumming: I would like to ask Mr. Collins if specifications make any other provisions than B.T.U. It has been my experience that sometimes coal with lowest B.T.U. is more desirable than that with the highest, containing some of the defects due to the fusible ash. Some plants are better equipped for low grade of fuel than others. I would like to know if any figures are contained in specifications to cover that argument.

Collins: That, I think, is pretty well covered in the specifications. That is, it is generally known what grade of coal is best suited for any particular plant and the specification is written and drawn up limiting competition to the particular grades of coal which are best suited to the plant. It may be determined in a preliminary way by either evaporation boiler tests or by previous experience.

Cumming: My questions are covered in that explanation, that each specification is drawn for some particular plant with a thorough knowledge of their equipment for burning the coal. I have been connected with the mining industry from my earlier days and I know both as producer of coal and as a user of coal that sometimes a coal is satisfactory in a certain plant but in another it is unsatisfactory because of the mechanical troubles involved.

Trow: A government station on the lake makes tests of coal. Samples are taken from the different grades of coal and taken to the laboratory and tests made. I should like to know what test is made.

Collins: I had a little experience with the plant a few months ago. In the plant mentioned they have not handled it in a very scientific way. They are now testing for heat value only. They have no fully equipped laboratory and do not make confirming tests for ash moisture, etc. The rest of the government institutions buy coal on the B.T.U. basis. Samples are sent to Pittsburg, where tests are made to determine heat value or B.T.U., ash and moisture. On these three things the value is determined.

Allen: I think this is a very important point. The B.T.U. is the heat unit in the coal. If you have the coal can you handle it right? Is your method of burning it all right to get that B.T.U. out of the coal? That is another problem. Now at present we are going into the determination of CO_2 gas, which means perfect combustion. CO gas is not perfect combustion. How many furnaces there are today that are burning a lot of coal and wasting a lot. The B.T.U. are going up the chimney. The excess air that you let through the grates is responsible for a great loss. You get 13 to 14% of CO_2 gas and if your boiler is clean and the circulation is perfect you get better results. Your conditions should not alter the condition of the B.T.U.

Trow: I had occasion to examine grates out here at our back door and there seemed to be lack of air space, 17 or 18% stopped up with ash.

Spaulding: In our city in the midst of a coal field where there are a good many mines, it is generally considered that there is little difference in the quality of the coal from the several mines. The price of coal that we burn ranges about $1.50 a ton. Would you consider that it would be profitable for us, using about 6000 tons of coal a year, to have it analyzed?

Collins: You are so close to the mines that you can almost regulate the delivery yourselves and be certain that you get coal from one and the same mine all the time. This B.T.U. system is really intended for people who have to receive coal coming in on cars. Then the additional cost of coal due to freight makes substitution mean a good deal more, and people fear that. For instance, we find cases where they are substituting an Illinois coal on contract for Pocahontas, mixing it in in small quantities with Pocahontas coal. The whole system is intended to cover conditions where they do not have conditions like yours. Without examining and studying the variation between one load of coal and another I could not say whether there would be a saving or not.

Orvis: We are receiving coal from Centralia and I would like to know the expense of making this test and whether it would be of advantage to us.

Collins: I do not know exactly what the situation is. The cost runs all the way from $15.00 to $200 a month, depending on the service wanted. Taking an average plant we do not make tests on every car, we take samples from four or five cars and bunch them together and make tests, in that way price is kept down. The price seldom runs over 2 cents per ton.

Anderson: There might well be included in the specifications a certain description covering the fusibility of ash and sulphur as well as B.T.U. A substitution of coal with suitable ash by one which has unsuitable ash is vastly more detrimental to the purchaser than would appear, simply from the difference of B.T.U. of the two coals. The deduction that Mr. Collins speaks of would be a very unsatisfactory basis in some instances on which to make compensation for discrepancies in the coal which mean mechanical complications in the boiler. While we utilize our B.T.U. it seems to me that it would be well to add certain restrictions very carefully drawn in regard to other details that he speaks of. We have some Illinois coals that contain a very fusible ash. Something which is termed Black Jack by the miners, under certain conditions stops fires, because the air space is absolutely blocked, and cuts down the capacity of the boilers. For a small amount of it you should make deduction in price to compensate for lack of evaporation in your boiler. That is one of the things which I had in mind, together with the fact that part of our coal had fusible action, burns our grate and makes an immense amount of work in removing it. Very rigid restrictions in that regard are equally desirable with the qualification of the B.T.U.

Collins: The subject of the fusibility of ash and its important relation to the ability of the coal to give good results on grates cannot be overlooked in the future. In fact scientific men are working now to try and formulate some tests which are practical to make and which will in a measure control and regulate this characteristic of coal.

Our specifications guard against this feature of coal by making it an obligation on the contractor to furnish coal from a certain definite mine, county or district. It is generally true that the variation in the fusibility of ash in coal from any particular location will not vary through a great range as to cause much trouble in burning due to this cause.

If it is ever definitely determined just what causes the trouble and if it is within the power of the miners and operators to control this feature we will certainly be glad to improve our specifications and attempt to keep pace with the progress in science.

EVANSTON'S EXPERIENCE WITH HYPOCHLORITE.

BY W. LEE LEWIS, PH.D.*

The city of Evanston is one of a number of North Shore towns suffering primarily from a lack of sewage diversion. The north branch of the Chicago drainage canal has now been completed two years, but Evanston, because of the cost attached to connecting up with the canal, and because of its limited remaining bonding power, is unable to avail itself of this much needed improvement. Up to the present time the Drainage District has not seen fit to come to the relief of the city in its local problem, and there seems grounds for legitimate differences of opinion as to the jurisdictions involved.

Evanston, with a population of 25,000, twelve miles north of Chicago, is located directly on Lake Michigan and is one of Chicago's richest and best appointed suburbs. After reviewing its beautiful residences, its educational institutions, churches and broad parked streets, the visitor is surprised to find that such a community empties its sewage directly into the lake and takes its water a mile and a sixteenth from the shore.

The municipally owned pumping station was constructed in 1873 and consists of three Holly pumps of 2,000,000, 5,000,000 and 12,000,000 gallons respectively; the consumption averaging 6,000,000 gallons per day. The water had never been treated in any way prior to December 19, 1911, although in 1909 the intake was extended from a half mile to the present point. The intake, which consists simply of inverted T's capped with small screens, lies in 34 feet of water and is within the wave zone. This condition gives a water supply that ranges from five to two hundred in turbidity, with a total bacterial count on agar at 20° of from 400 to 5,000 and gas producers ranging from five to twenty in 10 c.c. quantities. A typical sanitary analysis of the water is herewith given together with the normal for Lake Michigan as given by the Illinois Water Survey in Univ. of Illinois Bulletin 7-(No. 2) page 109.

*Instructor in Chemistry, Northwestern University, City Chemist of Evanston, Ill.

Sample	Chlorine as Chlorides	Nitrogen as free Ammon.	Nitrogen as Alb. Ammon.	Nitrogen as Nitrates	Nitrogen as Nitrites
Evanston City Water					
Nov. 18, 1911.......	6.00	.020	0.340	0.140	trace
Normal for					
Lake Michigan	4.5	.01	.08	0.04	.000

The following table gives the typhoid mortality of Evanston and Chicago from 1907 to 1911 inclusive, and shows that Evanston, despite its many sanitary advantages has consistently almost double the typhoid mortality of its neighbor.

Chicago		*Evanston*	
Year	Per 100,000	Year	Per 100,000
1907	17.5	1907	21
1908	15	1908	32
1909	12.5	1909	28
1910	13	1910	24
1911	10.8	1911	28

The following table shows the distribution for months of the Evanston cases for 1910 and 1911.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Cases	Total Deaths	Cases per 100,000	Deaths per 100,000
1910	7	8	19	4	5	4	4	5	3	8	2	0—	—69	6	276	24
1911	4	1	1	0	3	0	4	2	4	9	22	49	—99	7	396	28

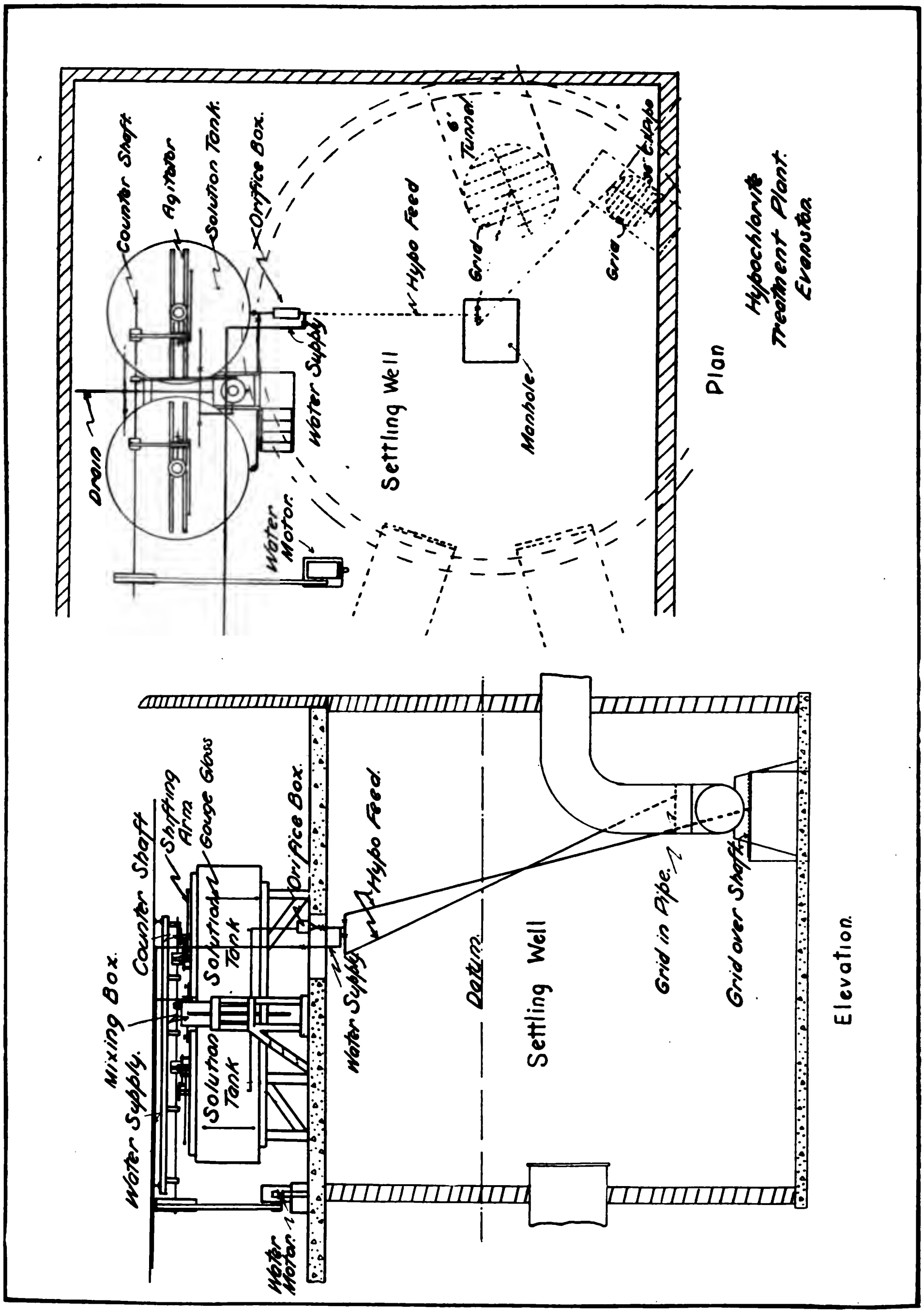
These results show for 1910 a rate 9% higher and for 1911, 27% higher than that of the average for the total registration area of the United States, as calculated for 1909—See Hygienic Laboratory Bulletin No. 77, page 20.

An examination of the Evanston health statistics over several years shows that our typhoid curve rises generally during the winter months. This fact in itself suggests water-borne typhoid as opposed to other avenues of infection. Several theories have been offered in explanation of the fact that our water supply, apparently subject to uniform polution, produces more typhoid in winter than in summer. A sufficient turbidity exists in the lake water to possibly set up a mild settling process in times of intermittent calm, thus acting as a protecting agent against pollution. Then in time of winter storms this same infectious matter would be stirred up and a disproportionate quantity

would enter the intake. It is quite certain that the water increases markedly in total count and B. coli with increase in turbidity. An examination of the composite chart will reveal the fact that the number of cases of typhoid reported during the fall of 1911 rose very consistently with the bacterial count. As for the later winter typhoid, it has been suggested that when the surface of the lake is frozen over the oxygen supply of the water cannot replenish itself, while the sterilizing action of sunlight, and the helpful action of motion are likewise inhibited. Again when the lake water is very cold, the warmer sewage may keep to itself and form surface currents which carry to the intake unusual amounts of organic matter.

In July, 1911, the Health Department of the city equipped a chemical and bacteriological laboratory and this was put in charge of the author. Daily bacteriological tests were made upon the water and weekly sanitary chemical analyses. During August and September the total count per c.c. averaged 500, with gas producers running about 8 in 10 c.c. During September the total count rose rapidly, reaching by the middle of the month 5000, with gas producers ranging from 10 to 20 in 10 cc. quantities. The condition of the city water was brought before the Evanston Medical Society by Health Commissioner Balderston, and this body in the light of these facts, and a rising typhoid rate, recommended to the city council water filtration with hypochlorite treatment as an immediate emergency measure. The council so ordered December 5th and the plant was in operation December 19th.

The settling well and wet wells at the Evanston pumping station are covered by a well house and it is here that the plant for mixing and applying the chemical was constructed. The plant consists of a mixing machine for making the hypo into a thin paste with water. The mixer is set so that the overflow drains into two wooden tanks 8 feet in diameter and 3½ feet deep. The mixing tank and dilution tanks are drained to a sewer with a 2″ wrought iron pipe. Power for mixing and stirring the dilution tanks is furnished by a Pelton wheel. The dilution tanks are set about three feet above the floor and are tapped on the sides about two inches above the bottom of the inside with a ¾″ galvanized iron pipe. The piping leads to an orifice box and is so arranged that the solution can be drawn from either tank or both tanks at once. The orifice box sets on the floor of the well house and feeds into ¾″ galvanized iron pipes leading to the grids. Below the orifice box a valve is set and below this valve a T through which a pressure pipe is connected. The grids consist of ¾″ galvanized iron pipes, T's and plugs, each lateral pipe having two ¼″ holes drilled in and placed on the down stream side of the pipe. One grid is placed



Plan of Hypochlorite Treatment Plant, Evanston.

over the top of the shaft, the other in the 36" T at the side of the well. By placing the grids at these points the water is treated when it enters the well and has about twenty minutes contact before reaching the suctions of the pumps.

The plant as constructed was made up of parts ordered by express from different manufacturers. The total cost, including a small outside shed for storing the chemical, was $750. The operation of the plant requires no extra help and but a small amount of work from the regular employees. At present 50 lbs. of the chemical are being used with 1420 gallons of water. After this mixture has been thoroughly stirred in the dilution tanks, it is allowed to stand for at least one hour before being drawn off. Considerable insoluble matter is always present which would otherwise cause stoppage in the orifice box and valves.

Each gallon of the above solution contains .0352 pound of hypochlorite analyizing 37% available chlorine. From the following formula the engineer operates his orifice box:

N=No. of gallons pumped per minute.

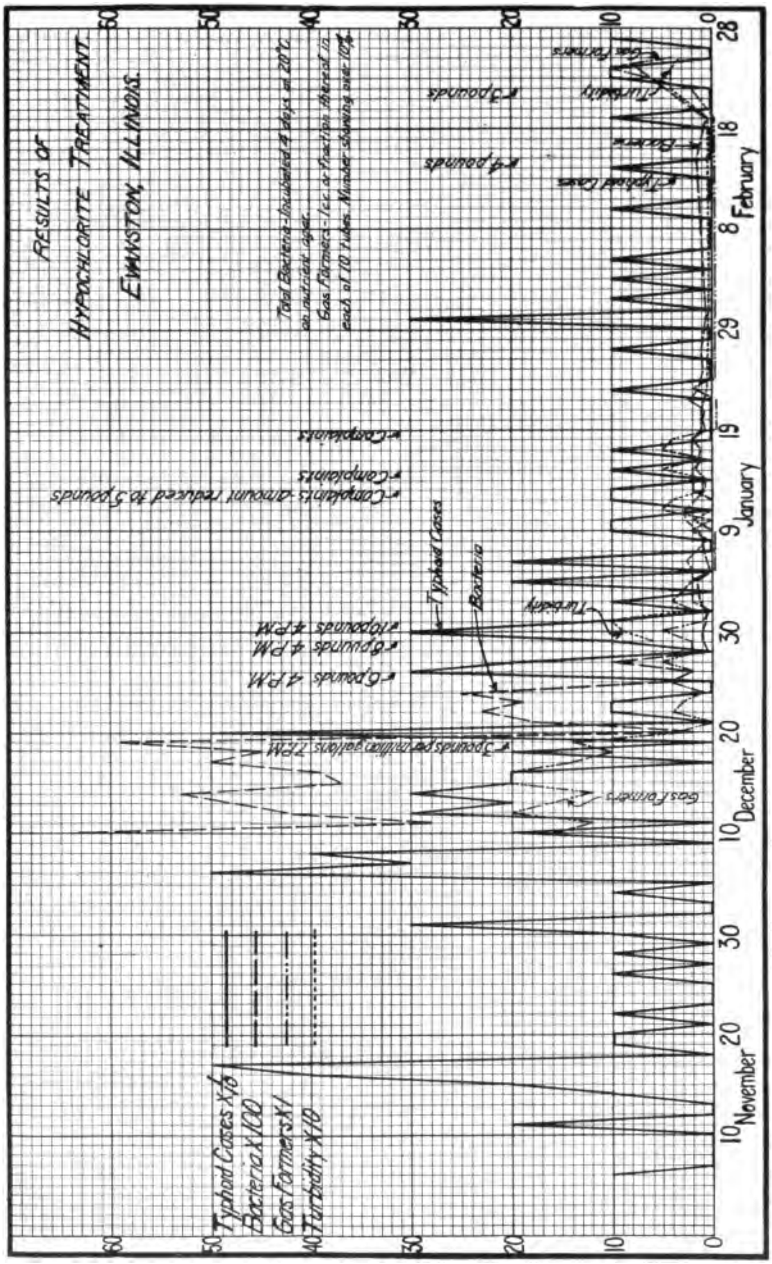
$\frac{1,000,000}{N}$=M or number of minutes to pump 1,000,000 gallons.

Q=No. of pounds of "hypo" to be added to each 1,000,000 gals.

$\frac{Q}{M}$=P. or pounds of "hypo" to be added each minute.

$\frac{P}{.0352}$=No. of gallons of liquid to be added per minute.

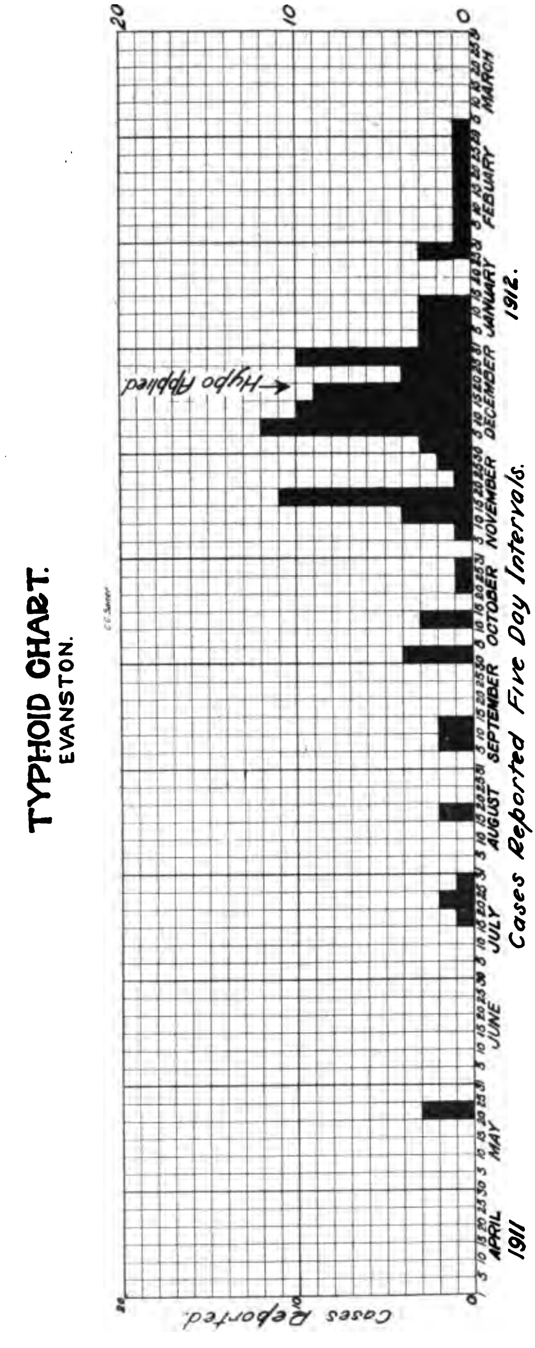
When any considerable variation in the speed of the pumps is noticed by the engineer, he counts the revolutions and determines the pumpage. The number of gallons of solution to be added is then calculated, and from a chart furnished by the manufacturers, the orifice box is set. Preliminary bottle experiments were conducted by the author to determine the appropriate quantity of "Hypo" needed for our special condition, but results were experienced that seemed quite anomalous. The experiments were conducted with amounts of 37% chemical corresponding to 5, 10, 15, and 20 pounds per million gallons. The raw water which was used for this purpose was running at that time about 5000 bacteria per cc. on nutrient agar at 20° with between 20 and 30 gas producers in glucose broth. (At this point it might be well to state that the author has experienced considerable difficulty in the use of gelatin on the Evanston city water, both raw and after hypo treatment. There seems to be a large number of the proteus group and of liquifaciens fluorescens in the raw water as well as in the



Results of Hypochlorite Treatment, Evanston, Ill.

residue from hypo treatment. Gelatin plates are uniformly useless after twenty-four hours and completely liquified in forty-eight hours. Litmus lactose agar at 37° and lactose broth have since been found more satisfactory for routine work.) Plating and tube inoculating was started immediately with a second party taking the time period between treatment, and plating or inoculating, in each instance. It was noted among other things, that gas producers often absent from a given treated sample in the earlier time periods would appear after the treated sample had stood from 30 to 40 minutes. The total counts showed little consistency and amounts of 37% chemical as high as 20 lbs. per million gallons were found necessary to effect reasonable sterilization. As the amount seemed hazardously high, it was decided to disregard the data and start the treatment with 3 lbs. of chemical per million gallons. The quantity was gradually increased, as noted in the large chart, until on December 31st, ten pounds were being added. Up to January 13th no complaints of odor or taste had been received excepting in one instance, now classical with us, that of a lady who claimed that the chemical in the city water had bleached her hair. Inasmuch as the chemical had not arrived in the city at that date, December 5th, the phenomenon was undoubtedly purely subjective. On January 13th, however, many bona fide complaints were received and the amount of chemical added was cut to five pounds. It should be noted that at the time a taste was complained of quite generally throughout the city, the plant was running under the same conditions, so far as we have been able to determine, as for the two weeks previous. No marked changes in temperature, turbidity or organic matter had been noted in the city water supply. Since that time scattered complaints have been received and the amount of chemical varied according to the condition of the water. Unfortunately turbidity was the only constant guide the chemist has had in thus prescribing the chemical. This was due to the fact that during our severe winter the shaft house from which alone samples of untreated water are obtainable, was frozen several feet deep most of the time. Such samples as were obtained showed the pollution of the water to be the same as at the time treatment was instituted. Past experience has shown, however, that turbidity has been a fairly safe index to such variations in organic matter and flora as occur.

That Evanston's mild epidemic of December was water-borne seems conclusive from the following considerations. It is generally recognized that epidemics occurring in the winter are traceable to the water supply, unless some other definite sources can be found. It is the season when fly contamination and vacation typhoid are largely precluded. A thorough inspection of the various milk supplies were



Incidence of Typhoid Fever, Evanston.

made, the farms and bottling plants examined, and the number of cases on each milk route compared with the normal average for the month. The question of infection from bottled waters, vegetables, shell-fish, etc., was given due consideration. Finally 90% of the victims were found to be users of the raw city water. Most striking is the fact that the cases fell off very rationally with the chemical sterilization of the water supply. The plant was standardized by December 25th and it was estimated that because of the incubation period of typhoid fever, returns should be noted by January 15th. An examination of the composite chart will reveal how well the facts and the theory coordinated.

In conclusion, the author believes from his rather limited experience with hypochlorite, which has been intensive rather than extensive—(See Engineering Record-Vol. 65, page 689—"Disinfection of Indoor Swimming at Northwestern University by W. Lee Lewis.")—that preliminary bottle experiments as to the quantity of chemical needed for a particular water are for some reason not a safe guide in its practical application. Furthermore while our experience as a city facing a rising typhoid rate has been on the whole eminently satisfactory in the use of hypochlorite, we have not been able to absolutely and continuously eliminate the gas producers as claimed by some. It may be that inasmuch as we undoubtedly have a rather fresh sewage in our drinking supply, the chemical exerts a selective action removing the more attenuated forms and passing some vigorous strains. Again particles of organic matter may pass through, which are only seared on the outside, thus mechanically enclosing virile organisms. Finally, it would be unfair to state that we had employed the chemical without noting taste or odor. Complaints have been more general from women, which may or may not indicate a greater sensitiveness on their part to the presence of hypochlorite in the water. Many complained that tea and coffee were undrinkable; a photographer stated that his solutions and prints had been ruined; still others blamed the water for an increased hardness and injury to the hands and face. While many of these charges are undoubtedly unjust, we do not deny that many were bona fide. Within the past few weeks the author has had opportunity to visit several cities where the hypo is used, both alone and as an adjunct to filtration, and he is inclined to think that the Evanston experience has not been unique in respect to slight discomfort with taste and odor. This result seems rare where hypo is used to supplement filtration and it seems reasonable to suppose that the time period of exposure where the chemical is added before the treated water goes on the filters, sets up very different conditions from that of direct injection into the mains as with us. Nor are our conditions comparable with

those at Jersey City; for example, where a considerable period elapses in the 22 miles of piping through which the water passes between treatment and consumption.

In conclusion, it seems to the author that hypochlorite should be made to stand upon its merits alone, as it well may do. It has never failed as an emergency treatment during a water-borne typhoid epidemic. And in recommending its use, better results will be obtained by taking the public into confidence, emphasizing the serious conditions which demand its application and otherwise preparing them for a posisble, slight and transitory unpalatableness at times. It matters not that the taste may be inconsequental in the minds of some and obviously harmless in a physiological sense, it is none the less real to many, especially women, and is undoubtedly distasteful to many in the highest degree.

As an association, interested always in a pure and wholly satisfactory water, the use of a chemical which under certain conditions may inevitably taste, should have its strong justifications and the approval of the consumers.

Plans for a large modern filtration plant suitable for fifty years of growth are now under consideration at Evanston and for its consummation Northwestern University has given two and a half acres of land on the lake front adjacent to the present pumping station.

DISCUSSION.

Dr. Lederer: There is one theory in regard to the possible reason for the winter typhoid in Evanston which Prof. Lewis has not mentioned. Winter typhoid has been noted on numerous occasions not only in cities using lake water but also in cities taking their water supply from sluggish rivers. In the latter cases the mud from the bottom probably could not have been the cause of an epidemic as might be the case with the lake water during a stormy season. Perhaps you know that a number of investigators as Jordan, Russell, Frost and Zeit have studied the vitality of the typhoid fever bacillus in lake water and found it only slightly resistant on account of the presence of antagonistic saprophytes. It has been recently brought out by Ruediger at the 1910 meeting of the Am. Pub. Health Assn. that colon and typhoid fever bacilli disappeared more rapidly from polluted waters during the summer months than during the winter months when the river was covered with ice and snow. This was said to be due to the small number of saprophytes and the lesened effect of sun-light. I believe that this theory is of great importance and it is very likely that it held good in many cases like the one at Evanston. It may at any rate have been an important additional etiologic factor.

Spaulding: I would like to ask Professor Lewis one question in regard to the way this matter was handled at Evanston. The supply, as I understood it, was taken into the well from which the city supply was pumped. How long did it take to reach the consmer from the time it was taken out of the well.

Hansen: I think that it takes about 8 minutes to half an hour, depending on the amount of water pumped.

*Dr. Ford:** We are using .7 of 1 part of chlorine per million. We are using this quantity because the results of our laboratory experiments show that this is the quantity that will give us a safe water supply. For the past two months our mortality from typhoid fever has been knocked out, which is very remarkable in a city of six hundred thousand people. There have been no deaths from typhoid in Cleveland for 60 days. Our water has been practically free from gas products for 90 days. The plant was installed in December. In January we had 16 cases of typhoid reported, which is about 30% of the normal. In February 6 cases of typhoid were reported, which is about 20% of the normal for the same month going back a number of years. Personally, I feel very certain we have done great work in Cleveland. We have practically eliminated water-borne typhoid.

Burdick: Hypochlorite has certainly been a very important addition to the means for the purification of water. I think that few people realize what hypochlorite can do for them in an emergency. If they did, there would be no complaint. Of course we dislike anything of the kind, but I feel that if the facts were presented to the people it would relieve much of the unpleasantness that comes through odors of hypochlorite in water. Take the case of Niagara Falls. Possibly you do not know that the typhoid death rate has been over 100 per one hundred thousand for ten or fifteen years. In a town of thirty or forty thousand people that means 30 or 40 deaths per annum due to typhoid. It is a resort visited every year by thousands of people. The consequences of badly polluted water at Niagara Falls must have been much greater than in most cases of water supply.

Another thing that should be thought of in connection with treatment with hypo is supervision. The price is so low that people get the idea that it is something that can be applied by inexpert operators. In filtration plants it is expected that there be a laboratory, with competent supervision, chemists, bacteriologists, etc. Money will be spent for chemicals to the amount of $1, $2, $3, $4 for each million gallons of water treated. If such are necessary for filtration, why not give the hypochlorite treatment also the laboratory supervision that is

*Health Commissioner, Cleveland, Ohio.

absolutely necessary, more necessary, in fact, in hypo treatment than in filtration; but yet in a majority of cases where it has been applied it has been applied without any adequate sanitary supervision.

Evanston has been fortunate in having Professor Lewis on the ground so that the city could obtain good service at a very moderate expense, but there is no reason why a larger expense should not be borne in a city where such a process is needed.

Jennings: Professor Lewis and Dr. Ford have brought up a point which interests me. It is in regard to determining by means of laboratory experiments the quantity of hypochlorite needed to produce satisfactory results. At Erie, Pa., in March, 1911, during the typhoid fever epidemic there, I made tests in the laboratory to determine the proper amount of hypochlorite needed to sterilize the water from Lake Erie. The results indicated that about 20 pounds per million gallons would be required. When the plant was ready to be put into operation, we started with a dose of 4 or 5 pounds per million gallons and gradually increased this to 8 pounds. The results with the first named amount were good, but we thought we could obtain better results. The counts under the treatment with 8 pounds per million were highly satisfactory and the dose has remained at that amount since that time. This is equivalent to about 0.3 parts per million available chlorine. As to the discrepancy between these two amounts, 8 pounds and 20 pounds per million gallons, I have two theories. First, the means for preparing the solution for laboratory experiments were insufficient to get the entire strength out of the hypochlorite, and the second, the amount of water we were handling, 1 gallon, was so small compared with the enormous volume that would be treated, 15,000,000 gallons per day, that there was sure to be a difference in the figures for laboratory work and for treating the water on a practical basis. I am in favor of laboratory experiments and make them frequently, but they are, at best, only an index of what may be expected on a large scale and one must be prepared for differences. I cannot understand why smaller quantities were not used at Cleveland when it was found that 20 pounds per million sterilized the water but produced a taste, showing plainly that they were overtreating the water. I feel that the hypochlorite of lime treatment, if carefully and conscientiously applied, will satisfactorily sterilize a water supply and yet will not produce tastes, as has been the experience at Cleveland. I would like to speak again of Erie, where the average bacteria in the treated water has been 15 or 20 per cubic centimeter, during the year that the plant has been in operation. A comparison of typhoid fever statistics before and after the installation of this treatment will be of interest:

	Number of Cases Reported		Number of Deaths Reported	
Month	1911	1912	1911	1912
January	239	8	24	1
February	510	5	56	0

Hansen: I would like to ask Professor Lewis if he has constructed charts for previous years. If so, how do they compare. And would like to ask also if he thinks he is getting a fairly uniform application of hypo with the methods in use in view of the fact that they have a direct pumping system at Evanston.

Lewis: As regards the charts we have not a duplication for previous years in this particular form. If Mr. Hansen had in mind the construction of charts which would give us an idea of the occurrence of typhoid with reference to the time of year, would say we have them back about 5 or 6 years. As mentioned in my talk, these charts show that most of our typhoid fever has been in January, February and March.

With reference to the reliability of our method of application, I believe that it is the best that can be worked out with any direct pumping system. I doubt if the method is accurate within ten and twenty percent. In the present state of hypochlorite methods, I doubt if this is avoidable. I understand there is on the market an injector which works synchronous with the pumps, but it is not in general use at any rate.

Orvis: I would like to ask a question. In the city of Waukegan, in which I live, there is a starch and glucose plant which discharges daily eleven million gallons of sewage into the lake. It contains large quantities of starch. In the discussion in the newspapers by several physicians it was declared that, because of the starch in the water, hypo is dangerous to the human system, that when the starch and the hypo meet in the human system it would cause a more serious condition to exist than would the germs. I would like to ask the chemists present if there is anything to this theory, as it is important to us.

Hansen: I would be willing to take a chance.

Maury: In answer to Professor Lewis's last remark, that there is no automatic device for regulating the supply of chemical, I would say that there is a simple and apparently satisfactory arrangement on the market. It is manufactured by one of the filter companies. I believe it is covered by a patent. It consists of a reciprocating chemical pump, driven by a reciprocating water motor. Each end of the cylinder of the water motor is connected by a pipe to one end of the cylinder of the main steam pump, and as the plunger of the main pump moves back and forth, pressure is applied alternately to the two sides of the piston of the water motor. This results in one stroke of

the chemical pump for each stroke of the main steam pumping engine. I have personally had no experience with the device. I am installing one now.

One speaker made a statement with regard to variation of hypo which should be explained by someone. The first part that came out of the can was very strong but by the time he got to the middle of the can there was no strength left.

Trow: At Lake Forest we purchased 600 lbs. of hypo in barrels. It was in wooden barrels and open to the air all the time. We use three lbs. per day and there was not much strength left toward the bottom of the barrel. When we put the hypo into the water there is a sediment in the bottom of the tank. Is there any method used for keeping it uniform throughout the tank?

Jennings: At Erie, Pa., the main solution tanks are built of concrete and have a capacity of 5,500 gallons each. The solution has a strength of ½% and after it is made up, it is agitated for about 6 hours with mechanical agitators driven by a water motor and is then allowed to rest. Only the clear supernatent solution is used because it is introduced into the lake water without filtration or sedimentation. I have recently had a letter from Mr. J. S. Dunwoody, who has had charge of the plant since its installation in March 1911, in which he said that by using this method, there was practically no difference in the strength of the solution between the beginning and the end of a run of a tank of solution, which lasts about 70 or 80 hours.

Clark: It has been disappointing that no one has taken up the question why hypo today is satisfactory and tomorrow brings forth such a storm of complaint.

We have discovered some points which bear on that situation. Our filter plant which had a capacity of twenty million gallons per day was about to be extended and would suffer some interruptions. Also the pumpage had during the preceding year gone to 24,000,000 gallons a day, and it was expected to reach thirty during the season covered by the contract for the extension. A hypo plant was installed to be used in emergencies as they arrived.

When the use of hypo was started it was found that it could not be used in such quantities as was desired without occasionally producing unpleasant tastes and odors. Upon going into the matter it was found that at certain times the water was devoid of free carbonic acid gas, which condition apparently prevented a proper decomposition of the hypo. In the drainage basin of Lake Erie there are a number of waters which a part of the time not only do not contain

free carbonic acid gas but carry a considerable amount of monocarbonates. In the Maumee River from which this water supply is obtained the monocarbonates have amounted to 42 parts per million and are present in lesser amounts during more than one-half of the year. At first the hypo was added to the raw water but did not give satisfactory results. Later it was added to the settled water shortly before it went to the filters. At this point the free carbonic acid gas resulting from the use of sulphate of aluminium as a coagulant was generally sufficient to permit the use of hypo without offense.

Other conditions some of which seem to be incompletely understood, affect the results sought to be obtained by the use of the hypochlorite. In some waters these conditions change without warning so quickly as to produce unpleasant effects while the amount of hypochlorite which had previously been satisfactory is unchanged.

It is to be hoped that sanitarians and especially those having public water supplies in charge will come to realize two things:—

First, that in the hypochlorites they have one of the most valuable aids in making a water supply safe and

Secondly, that the use of hypochlorite should be under the advise and direction of those skilled in its use.

In fact, I believe that as careful control of the water and the results should be maintained as would be required for the chemical and bacteriological control of a filter plant.

Monfort: In connection with the remarks of Mr. Clark it is well to refer to a paper by Rideal published some time since, in which he points out the necessity of free carbonic acid in order to decompose the charge of hypo if objectionable taste and odor are to be avoided. In too many cases large doses of hypochlorite have been applied rather recklessly disregarding the wide difference in waters treated, with results which were very unfortunate. One case comes to my mind where a large charge of hypo was applied to a partially softened water, causing immediate complaints from consumers that the water tasted and smelled like medicine. Another correspondent complains that even the smallest charge gave a persistent taste when applied after the use of lime and iron. While there may be satisfactory bacterial reaction without the complete decomposition of the hypochlorite added to a water low in carbon dioxide, there is abundant reason for discouraging the use of this disinfectant because of the troublesome taste and odor which persist in spite of hope.

Allen: How many are filtering and how many are not? I would like to get the results of filtration.

Jahns: Moline filters.

Trow: We are using filters at Lake Forest. We have been using hypo for over two years and have had no deaths from typhoid in Lake Forest. Someone said it was because the population was so small, but we have just as many to the hundred thousand. Had two mild cases last year and three cases this year, all but one of which were traceable to family wells.

Herdmann: I would like to inquire, in the use of hypo what the experience has been with the machinery at the plant and if it had any effect on plumbing.

Trow: We found that common iron or galvanized pipe from the hypo tank to the well would soon rust out, and have substituted brass piping with very satisfactory results. There is no effect noticeable upon the pumping machinery on other pipe work.

Lewis: Our application plant is out in the well-house some distance from, and roomed off from, the pumps. I have noticed that machinery in the room with the chemical is generally affected. Some household filters have a screen in the bottom of the charcoal chamber to retain the charcoal. This is supposed to be of German silver in the Ericson filter, which is quite generally used in Evanston, but last week such a screen made of copper, was brought to our laboratory highly incrusted with green salts. We have our suspicions as to the source of this formation, although we have not had opportunity yet to analyze it. There was no complaint of injury to pumping plant or the packing of the pump.

Mr. Langdon Pearse (by letter): I wish to congratulate Prof. Lewis on his paper, and the discussion it has provided. Three points of interest have been brought out, the variations in the amount of hypochlorite which will impart taste, the discrepancy between bottle experiments and actual runs, and the factors of the reactions taking place, as indicated by the presence of CO_2, and other gases or chemicals present. The amount of chemical used at Cleveland is very high, around 20 lbs. per million gallons. In November, the writer was there for a few days. The odor was noticeable in a bath room, following the agitation due to the flushing of a water closet perhaps three miles from the point of application. Apparently no studies were made under working conditions, to lessen the amount applied. In view of the careful control required, the steps outlined by Prof. Lewis, in giving publicity to the use, are highly desirable, to emphasize the necessity of its use, and the possibility under ordinary circumstances of noticeable taste. The time element between application and the use of water is also important. Further research is undoubtedly required to obtain a clear insight into the factors appertaining to the use of "bleach."

HYPOCHLORITE STERILIZATION AND TYPHOID AT KANSAS CITY, MISSOURI.

BY W. M. CROSS, M. D.*

Owing to the fact that there have always been present in the sedimented but otherwise untreated Missouri River water germs whose positively known origin and normal habitat is the intestinal tract of man and animals, the question has been an open one in the minds of many sanitary engineers as to whether or not the city's water supply should not be unreservedly condemned for drinking purposes unless it had first been boiled or sterilized. Indeed there have been occasions when the City Chemist has urged upon all of the citizens the advisability of boiling all river water before drinking it. Then to make matters much worse, many people began to use the clear and sparkling waters that issue in many places from springs or that can be pumped from shallow wells. These wells and springs throughout the settled districts of the city, although of very attractive appearance have been almost invariably the cause of disease at some time, and in most instances are at least ten times as badly contaminated as is the river water. Thus it happened that the city water, on account of its questionable character, became a possible direct and certainly an indirect cause of disease.

During the years of 1908-9 some experiments were made with ozone to determine, if possible, some practical method of sterilizing our entire water supply, at least as far as the destruction of germs likely to become the cause of disease is concerned. These experiments indicated that although it was possible to sterilize to a satisfactory degree all of the city water, the expense of installing the apparatus and the maintenance of it would be prohibitive. At about the conclusion of the ozone experiments, reports began to be circulated of the discovery of the process of hypochlorite sterilization, and the improvement of the entire water supplies of great cities. It was reported that in the case of Jersey City, the installation of the hypochlorite sterilization process, on such a large scale as to make possible the treatment of the entire water supply of that city, had

*City Chemist.

for its effect an astonishing diminution in the typhoid death rate. Then in rapid succession there came reports from numerous other sources of the remarkably satisfactory effect of this wonderful agent; which is able to destroy so efficiently by oxidization, those germs most likely to produce disease and death if taken into the human system by the drinking water route.

During the early part of the fall of 1909, the Fire and Water Board of Kansas City ordered the writer to make a tour of inspection of several cities known to have the hypochlorite sterilization system in satisfactory operation. Chicago and other places showed results fully as good as reported. The method of installation of the system was found both easy and cheap. It was seen that calcium hypochlorite assaying thirty-seven per cent of available chlorine and costing a little over 15½ cents was sufficient to treat a million gallons of a moderately polluted water.

The Fire and Water Board then immediately took steps to install this system of treatment to improve the entire municipal water supply of Kansas City.

In view of the fact that a great many cases of typhoid fever are imported and that numerous springs, wells and cisterns, known to be contaminated with sewage, are still constantly used, the result has been all that could have been anticipated. During the year 1910 no specific attempt was made to destroy pathogenic germs in the municipal water supply. During the year 1911 the hypochlorite process was used throughout the year.

The following tabulation showing the number of deaths from typhoid fever month by month during those years is illuminating:

DEATHS

Month	1910	1911
January	17	6
February	21	6
March	10	4
April	8	3
May	3	4
June	7	1
July	9	5
August	8	6
September	6	3
October	6	8
November	4	6
December	8	9
Totals	107	61

Now, with this great source of danger from infection by the municipal water supply removed, it is possible for the Health Commissioner to so enforce the abandonment of questionable sources of water supply and regulate sanitary conditions as to make the occurence of typhoid fever and most intestinal diseases an uncommon thing in Kansas City.

The following are some germ counts on the city water supply, showing the improvement of the water by the hypochlorite process:

Germs in 1 cubic centimeter of water:

Date	River Before Treatment	Clear Water Basin Before Treatment	Hydrant at City Hall After Treatment	B. Coli After Treatment
March 20........	10,000	1,200	75	0
March 21........	8,000	1,800	70	0
March 23........	4,000	800	100	0
March 24........	10,000	500	55	0
March 25........	8,000	600	90	0
March 27........	8,000	400	25	0
March 28........	5,000	260	20	0

TRIALS AND TROUBLES OF THE PUMPING STATION AND THEIR REMEDY.

BY M. M. SYMONS.*

I have taken for my subject the small things that come up in the operation of a pumping station, or in other words, what the engineer has to do.

CLEANING SUCTION WELL.

Before our filter system was installed, it became necessary to clean out our suction well. This well is 48 ft. in diameter; 19 ft. deep; walled with brick and the bottom 12 ft. below the river bed. There is a 20 inch cast iron pipe extending from the river into the well, turning down just inside to the bottom, continuing to the center, discharging through a 20 inch tee looking up. The deposit having settled for 13 years, had accumulated to a depth of 9 ft. at the outside and 3 ft. in the center. The pumps took suction at the side, so the agitation from the action of the pumps gave us turbid water when we should have had clear. In connection with our system, we have a reservoir which holds seven million gallons. The water was used from this reservoir during freshets. One of our pumps, being connected directly with this reservoir enabled us to cut our suction well entirely out of use. The first thing we did was to dig a pit 10 ft. deep on the outside of the well, cut a hole in the wall, put a 6 inch centrifugal pump in this pit, belted to an ordinary threshing engine, the suction pipe was made up with a swing joint, so it could be raised or lowered at will. A fire hose connection was made in the station and hose carried out to a raft in the well. Two men on the raft handled the hose. The water pressure being 100 lbs. stirred the mud up nicely, and it was then pumped out by the centrifugal pump. Water was admitted from the river, so as to float the raft and also to furnish enough water to keep the pumps in operation. At the end of three days, the work was completed.

INTAKE TROUBLES.

Our intake formerly consisted of a 20 inch cast iron pipe, extending out into the river. It had the customary one-quarter inch

*Chief Engineer, Danville Water Company.

mesh copper screen on a sliding frame, after the fashion of a window sash. Being a little below the bed of the river, it gave us more or less trouble from stoppage. During one of our April freshets, the water was quite high and lasted several days, so long that our supply of clear water was exhausted. It became necessary to turn the river into the suction well. Usually when changing from reservoir to the river, I filled up suction well and flushed the intake. This time I did not have water enough to overcome the head in the river, so had to open up without flushing; but to my surprise when the gate was open I got no water, there being 8 ft. of water over the intake at this time. Well something had to be done, and done quickly, so donning some old clothes, I proceeded to make an examination of the screen. Going down in 8 ft. of water in April is not very pleasant. After getting down, I found the screen covered with two feet of sand and a good strong current running. The next thing was to remove the sand. A shovel or spade could not be handled in that depth of water in such a strong current, so getting a common garden trowel, I went down again and commenced the task of digging the sand off. After 13 hours, of almost superhuman effort, I was able to get a clean spot on the screen; then taking a steel hook down, hooking on to the screen, connecting this by a chain to a two thousand pound chain hoist, pulled it off. This last act was at 12:00 P.M., and the first at 11:00 A. M. Now as you all know one minute is about as long as you can hold your breath, you can readily see that the work was very exhausting when the water was below 50 degrees F. But we got the water.

At another time this same intake gate gave us trouble. We had an A-frame dam, with a 40 degree pitch, anchored to a stone pier. The intake pipe came out through the pier, extending through the toe of the dam, up stream to the screen. The shut out gate was under the dam. A common six inch water main came up through the sheathing on the dam, about three feet out from the pier to enable us to open and close the gate. In January, we had our usual thaw out and freshet. The ice went out and also the valve stand. Valve was shut of course. The thing to do was to get the gate open. To get the gate open we had to get down to it. We built a triangular shaped box, open top and bottom, 12 ft. long at the base, 7 ft. at the top and 3 ft. wide, the sides being cut to the same pitch as the dam so as to fit down over same. This was built with an apron extending up stream to the toe of the dam so as to be partially submerged, thus the weight of the water helped to hold the box in place. We anchored the box up stream by an inch and one-quarter

line, setting the crib on skids and sliding it over the pier. As it had been built in the shape above described, the water running against it, made it hug the sheathing on the dam. Then it was a small matter to put in anchor bolts from the top to underneath side of dam and caulk the joint where the sides of the box rested on the dam.

TROUBLES WITH ICE.

Our present dam is constructed with four Tainter gates, 10 x 14 ft., to enable us to control the flow of the river. They have the usual form of hoisting gear, consisting of a worm screw and chain drum, making it fairly easy for one man to handle them.

When the gates were installed, a steam line was provided for the purpose of thawing the ice which naturally forms on any type of gate. We have had no difficulty heretofore in thawing the ice and raising the gates. This winter, however, has been a very severe one. There was no necessity for raising the gates until the middle of January. Then a thaw occured and it looked as if the ice was likely to break up. Upon attempting to thaw out the gates, it was found that ice had formed on the vertical face to a thickness of 14 inches, extending from the surface of the water to bottom of the gates, a vertical depth of 12 ft. I commenced to thaw the ice from the gate and had the top apparently loose. I commenced to turn the gear, and to my consternation it broke and fell off into the water. There was none nearer than Dayton, Ohio. I put the men at another one; they worked awhile, and while I was in the station, one of the men thought he would take a strain on the chains. Well he took it and that gear was broken; and there were two of them out of commission. I sent it to the shop and had it repaired. By the time it was back, I had fished the other one out and had it repaired and put on; then gave strict orders not to attempt to raise another one as long as there was any ice visible. The down stream side of the gates are exposed to the weather. The front side of the gates are under 12 ft. of water. This freezing to the side piers made thawing them out very difficult work, but bending a ¾″ pipe, the same arc as the front of the gate, faciliated the work, and after 5 days of cold, disagreeable work, we succeeded in getting them open. This shows the necessity of thawing the ice from time to time and not allowing such a heavy accumulation to form. Since that time, by a little work from time to time, the gates have been kept free and ready to raise in case they should be needed immediately to take care of the moving out of the ice in the river.

ELIMINATION OF OIL FROM CONDENSED WATER.

The present management on taking charge of the Danville plant, found the tail water from the condensers going into the sewer, and on investigating, found that the condensed water returned from the pumps to the boilers contained oil which was left in the boiler. Condensed water is too valuable for boilers to waste into a sewer, so we began to experiment a little. The first thing was to reduce the oil about 50%, then by catching some of the water in clean pails and letting stand for 24 hours, we could see the amount of oil on top and get a line on it. The company was contemplating putting in a filter of a very elaborate design with linen filtering tubes, and a sand bed, which would cost in the neighborhood of $500.00. The superintendent suggested that we make one ourselves; and see what results we would get. We had an iron tank 4½ ft. x 4½ ft. x 5 ft. made of one-quarter inch plate, this tank being an old exhaust tank, not in use. In the store room there were 100 of the New York Continental Jewell strainers, which were used for our strainers. Taking 2½" nipples and 2½" x 1¼" tees, a header was made to fit inside and along one side of the tank. From this header were laid 5-1¼" pipe laterals extending across the bottom of the tank into which laterals the filter strainers were screwed on 7" centers. The strainers were covered with 4" of gravel and about 2 ft. of sand from the filter beds. Then in order to prevent the water from going through too fast, the discharge pipe was made with a vertical riser coming up on the outside of the tank, higher than the sand on the inside, and still leaving a good head in the tank. This filter is washed just as the large filters are washed, by reversing the filter process; that is, by shutting the inlet to filter and forceing clean water up through the straners and sand bed. It was put into operation on our No. 2 pump, and after running awhile we found it so satisfactory that the No. 1 pump discharge was piped to it. The trap from the heating system was also piped to it as we use exhaust steam in the heating system. The cost of the installation was $8.35 instead of $500.00. It has been in use over two years with no trace of oil in the boilers.

ERECTING SMOKE STACK.

At one time it became necessary to erect a new smoke stack, the old one having rusted out and part of it fallen. The new stack was built in two sections to facilitate transportation. The two sections were riveted together on the ground. Tackle and everything was made ready, a gin pole put up, a hitch was made to what was left

of the old stack, the furnaces were filled with coke and shut up, (ordinarily two boilers were ample for the operation of the plant, but under these conditions, it was necessary to operate the four boilers) in four hours the old stack was down, the new stack up, the tackle all down, plenty of steam and everybody happy.

ECONOMIES.

How we oft times look at the first cost and do not figure on the results of the saving. The writer has in his plant four boilers; two horizontal tubular, 18 ft. x 6 ft. with 70 four inch tubes; two Scotch marine boilers, 1/8 ft. x 13 ft. with a 50 inch Morrison corrugated furnace, and 1-12 x 14 with 2-42 inch Morrison furnaces, the latter having a Hawley down draft furnace attached to it, making it the most economical boiler in the plant. In rolling the tubes three of them split and had to be removed. The usual method of repairing tubes in such cases is to weld them out. On Tuesday it was found that the shop could not do the work for 10 days. It was decided that new tubes be put in for economy's sake. Wednesday noon the boiler was under steam and in operation. Now for the financial side of the transaction: The tubular boilers consume 4000 lbs. more coal in 24 hours than the Hawley furnace. We would have been without the Hawley furnace 9 days, and would have used 36000 lbs. more fuel at $1.60 per ton, amounting to $28.80. The new tubes cost $4.60 each, less $1.50 for welding the old one, making the actual cost of the new tubes $3.10, or $9.30 for the three. The labor of putting them in was the same in both cases, making a clear saving for the company of $19.50, or 48% on the investment. At another time, changing the exhaust of a boiler feeder from the sewer to a Beryman heater, raised the temperature of the feed water 40 degrees, thereby saving 640 lbs. of coal in 24 hours. Coal costing at that time $1.10 per ton, a saving of 116.68 tons at $1.10 per ton-$128.48 annually. It cost $1.60 to make this change.

At another time the writer experimented with the different ways of running packing on an outside packed plunger pump. The plungers were 12½ inches in diameter. I found that by running them with a good slip as against no slip, made a difference of 6 H. P. with indicator cards taken under both conditions. With our rate of evaporation, and coal costing $1.25 per ton at that time, a saving of $118.12 per annum was in favor of plungers slipping.

The writer on taking charge of a central station, found the feed water heater running over in the sewer continually, keeping the water at an average of 110 degrees temperature. After having stopped the

waste, the feed water was raised to an average of 200 degrees. The plant was putting out on an average of 42000 kwh. per day, consuming 121 tons of coal, or an average of 6 lbs. per kw. After the change there was reduction of coal to 5½ lbs. per kwh. a saving of 10½ tons at the price of $1.10 per ton amounting to $11.50 per day, or $4,197.50 per year. In other words a 5% saving on $83,950.00.

DISCUSSION.

Gwinn: I would like to ask Mr. Symons if his experience with the Holly furnace has been entirely satisfactory from the standpoint of firemen as well as from the standpoint of economy of fuel.

Symons: I had quite a bit of trouble with the Holly furnace for the first two years it was in operation and had quite a time to get men to work on it. I repaired it over two years ago and have had no trouble since that time. I have no trouble with firemen at all. They would rather fire Holly furnaces than others.

Hansen: Do you have any trouble in keeping the top sand clean.

Symons: The sand does not bother us. We have about 14 inches of sand over the strainers and our engines are compound engines and do not use a great deal of water.

Hansen: Does the sand get black?

Symons: It was black when put in.

WATER DEPARTMENT METHODS.

BY W. J. SPAULDING.*

The membership of this Association is perhaps about aqually divided between those operating private and those operating municipal water plants. It might be said that I am a representative of the latter class, and if any statements of mine would indicate a leaning toward public as against private ownership, it is in no wise meant as showing discourtesy, but is intended only in the friendliest spirit. Indeed, I can imagine myself owing or operating a private plant, in which case, I would probably be pointing out the advantages of private ownership as against public ownership.

I hope no city in the State which owns its water plant is so unfortunate as to have it in charge of officials who do not believe that the city can successfully operate such a utility. Such officials are very apt to proceed to demonstrate by their management that their opinion is right. There are some who believe, for instance, that a municipal days work is one thing, and that an honest days work is quite another thing. One of the hopeful signs of the times is that this notion is being more and more disproved.

It may be of interest to refer to some of the work done in the Department at Springfield recently. There are four subjects to which I wish to invite your attention,—the installation of meters, free water, main extensions, and putting in service pipes.

INSTALLATION OF METERS.

In the average American city I think the use of meters is almost indispensable. They are especially an advantage here because extravagance is characteristic of Americans. We are also impatient and intolerant toward what might be considered petty regulations. Rules regarding the use of water, which I understand are strictly enforced in some European cities would be looked upon here as pestiferous. The meter will automatically and effectually do the work of many rules and inspectors. In Springfield we were short of water and have not provided enough yet. It seemed to us that to expend large

*Commissioner of Public Property, Springfield.

sums to develop our plant and increase the supply, while a large portion of the daily pumpage was getting away without doing anybody any good, would be like adding waste to waste. Our first step, therefore, was to install meters. This was at first left optional with consumers, but was encouraged in two ways,—first, by the city furnishing the meter at its own expense and maintaining it so far as ordinary wear and tear are concerned, and second, because the consumers usually enjoyed a saving over the old fixture rate.

Last April our city passed an ordinance requiring all services to be metered within two years. On March 1st last we had about twenty-two hundred meters in use. March 1st this year we had about five thousand in use. Our daily pumpage has been steadily decreasing, and we have been able to supply the city from our wells regularly for the past six months. While we had to meet a good deal of prejudice at the start, I think it is safe to say that fully three-fourths of our consumers are satisfied, and more are being converted every day. I am told that in one large city the past season the supply to all residences was cut off at the curb key to save the water for fire protection. Later the installation of meters was begun. Had this city been on the meter system probably this drastic measure would not have been necessary. Other cities have been reported in almost as desperate straits.

It is only necessary to make the patrons understand that conservation means in the end lower rates and better service for them. The proposition is simple. For example, if ten million gallons are pumped through the mains, and only five millions devoted to legitimate use, the five millions of waste must be added to the bills of consumers the same as if they had used it. If those five millions which were wasted had been sold, it is obvious that the rates could have been reduced fifty per cent and the Water Department still have received the same gross income, less the cost of additional mains.

One matter that should not be overlooked with reference to the meter system is that a meter is a machine and will get out of order. A water system had better not be metered at all, at least from a revenue standpoint, if the meters are to be installed and then allowed to take care of themselves. I think it is a serious mistake for the consumer to own the meter. The Water Department should own, install, and take care of it, and so keep its records, that it can know the history of every meter from the time it was installed down to date. Our experience is that meters seldom get fast, but continually become slow. In the past summer we started a test of all meters which had been in service more than two years. The test was made

at the premises. These tests showed that about four meters out of five were from five per cent to ninety per cent slow. It should be explained, however, that these meters had been in use for from two to twelve years. Most of them had been in service eight or ten years. To illustrate, we removed a meter which had been yielding seventy-five cents per month in revenue, and replaced it with an accurate one. The revenue at this place rose to thirteen dollars. Reference to the ledger showed the registration from that meter had been gradually falling off for several years. Of course, the consumer felt greatly aggrieved and assumed that he was being robbed, but was finally convinced that he was wasting a great deal of water and by a change in management cut his bill down to about four dollars per month, which in his case, might be considered normal. This is only one of many similar cases. I think it is safe to say that on all meters that had been in use more than eight years we were losing on the average forty per cent in income. Tests for accuracy should be made at regular intervals, not more than two years apart. We expect to follow up the work of installing and to complete it this summer.

FREE WATER.

In our city, as in many others, free water was given to various institutions from the beginning, and these were added to from time to time, until we had a great many such consumers. We have a park system which is provided for by a State Law. The revenue is provided for by a special tax levy. It is no more fair for the Water Department to furnish them water free than to pay for the park policemen. The Water Department is under no more obligation to furnish the public schools free of charge than to pay their janitor. It is no more entitled to furnish the cemetery with water than to pay the grave digger. In our city we have put these and a number of other free consumers on the pay list. At one school building when the meter was first installed the consumption was at the rate of about seventy-five dollars per month. This, of course, was largely due to leakage.

In this matter of free water there is a question of equity which is often overlooked in municipal management. It is assumed that a water plant should be self-sustaining, and on this point there is no argument. If the funds of the Water Department are diverted to other uses, it is obvious that in that case water consumers are being made an object of special taxation indirectly through the water rates. For instance, suppose that the water rates were placed high enough so that the revenue would not only support the water plant,

but would pay the cost of maintaining the fire department also. Then a citizen would be taxed to support the fire department, not in proportion to the property owned, but in proportion to the water he used, and a substantial portion (say one-half of his water bill) would really be a charge for fire protection, and fire protection for the whole city would be paid for by water consumers, while nearly one-half the people enjoy the same protection and pay nothing. The furnishing of free water is only another method of diverting the funds of the Water Department away from their proper channel, and to that extent an unfair burden is being placed upon those who pay for water. On account of its importance from a sanitary standpoint, we can not fail to see the urgency for promoting the general use of a public water supply, and the most certain way to do this is by making it as cheap as possible. A city cannot be made beautiful or sanitary until every working man can enjoy the advantages of city water. In our city only a little more than half of the residents are water takers, and one of our problems is to increase the number.

MAIN EXTENSIONS.

The matter of water rates, however, is of no greater importance than the necessity of making the service easily available. That is to say, the distributing main must be accessible to the prospective consumer, and the installing of the service pipe should be made as easy and inexpensive as possible. Home builders can not take city water if there is no main within reach. At the same time, any water department can easily bankrupt itself by draining its resources for water main extensions from which there is insufficient revenue. One of the problems now before our Water Department is the question of how best to provide revenue for extensions. In the past we have been meeting this expense from revenues. In a prosperous and growing city the cost of water pipe extensions commonly amounts to about twenty-five per cent of the gross income.

There are three ways in which this expense may be met,—from water revenues, by bond issues, or by special assessment against the frontage. In the first instance water consumers foot the bill directly; in the second it becomes a permanent interest bearing obligation against water patrons. By either of these two methods, it must be provided for in the rates. By the third method it is paid once for all by the owners of the property benefited, and in that case the rates for water could be reduced approximately twenty-five per cent, and at the same time leave the Department the same net income. In the past two years we have had some large additions laid out in the

residence part of the city. These additions were not available as home sites without city water. Since there were no consumers immediately to be had the Water Department refused to make extensions. The owners of the additions concluded to lay the mains at their own expense, and the argument to justify the expenditure was as follows: Investment for water pipe in front of these lots would amount to about fourteen dollars for each forty-foot lot; for the expenditure of fourteen dollars on the lot its value was enhanced at least double that amount, so that as a matter of fact the investment in water pipe paid a profit of one hundred per cent to the owner of the frontage. As the lots were sold, the real estate dealer received the money he had invested in the pipe, together with one hundred per cent profit on it, so that the Water Department surely could not be said to be in debt to him. Therefore, no refund was made. Now under the old method of paying for the water pipe from the water revenue, the lot owners would have collected the value of the water pipe from the home builder just the same. Then the home builder who improved the lot by putting a house on it would proceed to pay for the water pipe in his water rates as soon as he had become a water consumer, notwitstanding that he had already paid for the pipe twice over when he bought his lot. This would seem to be a ridiculous inconsistency which penalizes the home builder in favor of the lot owner, and at least in the case of municipal ownership could just as well be avoided. The cost of sewers and of pavements is acknowledged as a legitimate charge against the frontage and is paid for accordingly. The value of a water main in front of a lot is much more certain and tangible than sewers or pavement, because there is scarcely any business or purpose for which the lot could be used that water would not be necessary or desirable. It is like bringing an ever-flowing spring,—and flowing under pressure,—within reach of the lot. Though a resident may use no water at all, the fire protection means an annual saving in insurance. It is perfectly natural that a real estate owner should capitalize the value of a water main and charge it to the home builder who buys the lot, just as he would charge for a sewer, a pavement, or a boulevard. Therefore, what is more logical or fair than to require him to pay for the main in the beginning, since he gets the money back with perhaps one hundred per cent profit?

Charging water pipe to the frontage is not new in this State, and is quite general in Minnesota; but there they have a method of spreading the cost over a period of ten years, collecting the amount with the regular tax assessment, which makes the annual charge so

small that it is scarcely noticed and makes the collection in a very inexpensive way. The advantages to a city of some such method is far-reaching. Under such a plan, water pipe could be extended in all directions as new additions were laid out, instead of being held back until such time as there are enough consumers to make the extension profitable; thus avoiding the unfortunate necessity of compelling many home buildlers to provide a well and outhouse on their lot. Finally when the main is extended, often a large number of residents have become settled and satisfied, and will not put in the service. Many persons in planning a new house will put in city water but the same persons would not rearrange an old house. This method accomplishes three things of vital importance,—first, it makes the water available to those who want to use it; second, it reduces the cost of water in two ways; namely, by relieving the water department of the cost of extensions, and by greatly increasing the number of patrons; third, and above all, it is the most equitable plan yet devised.

PUTTING IN SERVICE PIPES.

A weak feature commonly found in the administration of public water works is the installing of service pipes by the plumbers. In our city it has cost from thirty-five to fifty dollars to install a service pipe. This is about double what it would be if the Department did the work at actual cost. A water plant should expect to earn its revenues from the sale of water, and should therefore be interested in making it as easy as possible for citizens to obtain the service. With that idea in mind our city council introduced an ordinance providing that all services shall be installed by the Water Department at cost. By this means we are enabled to make a uniform charge which applies to both the long and short services alike; so that the resident who happens to be on the long side of the street will have to pay no more than if he were on the short side. This was not done without stirring up a good deal of trouble with our local master plumbers, who wanted to retain this business. We were charged with having sinister designs of personal gain, and threatened with various kinds of political destruction. But these are only incidents in the days work that we must get used to. We do not take an attitude of opposition to union labor, however. On the contrary, we prefer to employ union men.

POLITICS AND WATER WORKS.

To furnish the best service at the lowest possible cost should be the ambition and persistent effort of the water works manager, whether

of a public or private plant. Approaching the subject with this purpose in mind, here is found a vast field for human endeavor and public service, full of interest and often presenting some very perplexing problems. I think it is a mistake on the part of a manager to underestimate the importance and magnitude of this kind of work. It is better to overestimate. I once knew a water department chief who said a water works would run itself—that he only took the job to get two years of good solid rest; but that plant ran down very rapidly in those two years.

It is true that most any man has intelligence enough to pump water, but there are many different ways that the pumping might be accomplished; thus a high order of mechanical and hydraulic engineering may be exercised. There are many kinds of water, some very good, some very bad, and all the grades between, this matter of quality involves the science of chemistry. There are many ways of collecting water from the water-bearing strata, which involves a study of underground conditions. There are various ways of distributing it and collecting for it, which involves good business sense. There are various schedules of water rates, some very fair, some very unfair, which involves a sense of justice, and there are various kinds of politics that may or may not mix into our programme; but this, as I see it, is no longer a question of parties, but involves a choice between patriotism and commercialism. It may be assumed that with reference to politics the private plant has an advantage, but this is not true by any means, for they are usually in politics quite as much as the publicly owned plants, not because of any wrong intent, but merely to protect what they conceive to be their rights and interests. I think we both sometimes feel the pressure in ways that are very disagreeable and want to free ourselves from it, but if I may be allowed to prophesy, we can not and never will separate public service business from politics. On the contrary, as our cities become larger, rendering the individual more dependent and helpless, the importance of public service to the common weal increases, and political action becomes more and more necessary. In connection with public service corporations, politics and political influences are often blindly condemned. It is true, there is more or less petty sand-bagging and pestering by small men in positions of authority that should be stamped out. However, there is, and should be, a close and active relation between the public service corporation and the public whom it serves. If it be called the relation of master and servant, then the public should be the master. Politics is the agency for public expression and action, and this relation had better be recognized than resisted, because if it is not a full reality now, it soon will be.

To take the corporations out of politics it is proposed to place them under control of a State Commission. State supervision within certain limitations would no doubt be a mutual advantage to all concerned, but we may rest assured that such a change would be merely a transfer from local to State politics. Every manager has his problems that are peculiar to his city.

There is no public service which so intimately touches the daily life of a community and it is highly important that friendly relations be maintained between the manager and patrons. Realizing this, managers are prone to follow beaten paths or to retain methods that are obsolete for fear of arousing public or political opposition.

The manager of a municipal plant often feels that his political life is at stake and acts a good deal like the Irishman in battle when he was charged with cowardice. He said he would rather be a coward for five minutes than a corpse for the rest of his life. The position of the manager of a private plant is not to be envied either, for he is expected to maintain a kind of poise or hold in equilibrium two conflicting interests; i. e., that of the public and that of his employers. He is much like a man trying to walk a tight rope,—if he leans too far either way he gets into trouble. It is very natural for us who hold our position subject to the fortunes of politics to shun any policies which invite unfavorable criticism, even though we know them to be in the long run of great practical value to the patrons as a whole. However, in my rather limited political experience, I have observed this: namely, that a few persons who may be affected adversely by a change of method, and there are always some of those, often exert an influence out of all proportion to their number. The average citizen is honest and fair and is interested in efficient government, especially in an efficient water department, and will, nine times out of ten, back up any honest progressive measure if given a reasonable chance to understand it. When we complain that we cannot adopt this or that step in economy or toward equality on account of politics, let us try to be sure that we are not standing in mortal fear of a man of straw. And after all, the over-cautious may be rebuked for doing nothing. It is better for an official to act and to act promptly, even if sometimes unwisely, than not to act at all.

Under public ownership the Water Department becomes an arm of the government. The purpose of government, and in fact the only excuse for government as I see it, is to preserve equitable relations between the individual members of the community. The working out of some phase of this great and comprehensive purpose is the function of each official whether important or humble. In adopting or

proposing policies in a water department the first consideration should be,—are they equitable and will they promote the common good. We cannot have things ideal but we can draw a picture or a blue print as it were of an ideal and work toward it, and at least leave things a little better than we found them.

DISCUSSION.

Lewis: The subject matter of this paper lies entirely without my technical knowledge, but I happen to know that the question of meter installation is a burning question just now at Evanston. The issue has been forced as a part of a proposed filtration plan; some of our aldermen refusing to vote for filtration unless the city is metered, maintaining that filtered water is too expensive to waste. Our average pumpage is 6,000,000 gallons per day with a population of 25,000 people. On the other hand the reduction in revenue incident to a change from flat rates to meter rates is a serious consideration. Might I inquire of Mr. Spaulding if they have experienced any considerable net reduction in revenue.

Spaulding: We are not experiencing any appreciable reduction in income. The 40% referred to was on account of meters being out of order. Meters should be constantly watched and tested and kept accurate to avoid loss. In our case the maximum meter rate is 25c with 10% discount for prompt payment, and our fixed rate was perhaps an average fixture rate for the State of Illinois. I hardly know how to fix the rate, about $10.00 per service on the average.

F. C. Jordan: There are two statements that most impressed me. The elimination of that which we have termed "free water" and the care of meters. We have tried in Indianapolis to eliminate free water. We came across one case the other day which demonstrated to us in rather a marked fashion why we should eliminate free water. We were furnishing two of the parks with water. Pitometer tests showed records rather high in one district due to a fountain which was running about 50,000 to 60,000 gallons per day. We cut down this supply and then came face to face with a complaint. A citizen informed us that the fish in the pond had to have a certain amount of water or they might die. I try to take trips to find how many more mistakes we make in Indianapolis than in other towns and have come across towns in which they have regular appreciation of the care and value of meters. The man in charge told me that the larger meters for the larger consumers were read every day and he said that they know now by putting on tested meters what ought to be used every day. I was impressed by the great care taken.

I went to another city where they had fifteen to twenty thousand, a large percentage owned by the people. Some ludicrous things came up. A woman came into the office and proceeded to state that they had not replaced the same meter which she had. Her meter was bright red and the one they had brought was a black one. Could not make her believe that the company had been blackening the meters. But the thing that impressed me in this department was the fact that they read meters every six months. The statement that the department loses at least 25% by keeping to the practice of reading meters every six months when they would not have the opportunity to watch the meters as if reading them once every month.

Orvis: I would like to ask the gentleman the method used in testing meters on premises.

Spaulding: One method is to take a vessel which will hold a certain quantity of water, disconnect at the meter and pass the water through it into the vessel.

Gwinn: I would like to ask Mr. Spaulding the cost of laying their lead service pipes.

Spaulding: Our present system is simply that plumber makes a contract with each individual at a cost of $35 to $40 to bring the water from the main into the house.

Gwinn: We do the work for $8.00.

Spaulding: What kind of service do you have?

Gwinn: We use ⅝" extra strong lead pipe with the inverted key curb cock and Buffalo service box, all complete, either long side or short side, on unpaved streets for $8.00. We have a club rate where there are four services being put in in the same neighborhood at the same time of $7.00 each. Please note that this is to the curb only and not into the house.

If a customer wants a hydrant in the yard, say 15' inside the property, we put in a ¾" x 4' anti-freezing hydrant at the same time we are laying the pipe to the curb for $6.00 additional, making a total of $14.00 from the main to a point 15' inside the yard, including the hydrant. Where a neighborhood club is made up, this work is done for $12.00 each. We do not expect to make any money on service work.

Spaulding: We carry the service into the house. We have not yet made much progress, having only just introduced an ordinance providing that the water department shall lay all services to the curb. We prefer to take services into houses. Where meters are put on we think it is the proper way to do.

McGonigale: Does the consumer pay the expenses.

Spaulding: Yes, the consumer bears the expense but only the actual cost of the labor and material.

Smith: I should think that there would be a great loss in revenue in changing from the flat rate to meter rates and I would like some of these gentlemen to answer the question along that line.

Parkin: The only way for him to tell that is before he starts, whether his returns correspond with the service that he is going to render in comparison with flat rate. If he puts in a meter rate of 4c to 8c, he will make no money. We have pumped, as my paper showed, less water in December, 1911, than we did in December, 1909. We are now pumping for 4900 consumers less water than we pumped for 3000.

Gwinn: We have 750 domestic consumers supplied by meter, including 194 boarding, rooming, and apartment houses. On the flat rate basis, the entire lot would have paid about $15,339, while on the meter basis, the amount paid for the year 1911 was $12,052, a saving of approximately $3,287, or an average of about $4.38 for each customer.

Some might consider this an argument against the use of meters from the Water Department or Water Co. standpoint, but we do not look at it in that way. In view of the large cost of purifying water and furnishing it under high pressure, it is absolutely necessary to keep the waste down to the minimum. We do not know of any method quite so effective in reducing the waste as the installation of meters under certain conditions. We do not consider the loss of revenue to be a very serious matter, for while we did get less money from this class of customers, we also saved a great deal of water. During 1911, our cost of coagulants for purifying the water was 50% greater than the cost of fuel. Every gallon of water which we deliver to our customers must be treated with a coagulant, sulphate of aluminium being used, and in addition to the coagulant, we are using hypo. Whenever the water in the river is muddy, it must be pumped the second time so that by the time it reaches the customer, it may be considered as a manufactured product.

Allen: Is it not a fact that the greatest reduction is the first year of the meter and after that the meter customers increase the revenue?

Gwinn: This does apply to a certain extent in manufacturing and commercial business, but I do not think that it is true in the dwelling or domestic business.

NEW DEEP ROCK WELLS AT JOLIET, ILL.

BY H. A. STEVENS.*

For nearly twenty years the City of Joliet has been confronted with a problem of ever increasing importance, to-wit, the securing of an adequate supply of pure water at a cost within the limits of its financial resources.

In 1889 the city acquired by purchase the plant, mains and equipment of a private corporation then engaged in supplying a limited section of the city with water. This company used as a source of supply, ground water furnished by springs and ponds and the water obtained from one or two small artesian wells. After obtaining possession of this plant the city started to develope an additional supply in various ways, principally by the sinking of deep artesian wells but also from a group of driven wells extending into the gravel about forty feet, located on a five acre piece of land adjacent to a small stream called Hickory Creek. In the next ten years six artesian wells, varying in size from four to eight inches and having a depth from 1200 to 1800 feet, were put in operation, all being located within a radius of a few hundred feet from the pumping station.

The aggregate production from these six artesian wells was about 1½ million gallons in 24 hours and the drive wells probably added as much more to the supply. However with the rapid extension of the distribution system and large increase in the number of consumers the total available supply began to be totally inadequate, especially during the summer and winter months and in case of large fires.

Various expedients were adopted to relieve the situation; a reservoir was constructed, a large air compressor was installed, with the belief that more water could be obtained from the deep wells. At the same time extensive surveys and investigations were made of eight or ten possible sources of supply.

A plan was finally adopted which would entail an expense of about a quarter of a million dollars to complete. The expense was to be provided for by the sale of special water improvement bonds, the

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issue of which was authorized by an act of legislature. No sooner, however, were we ready to let the contract for this work, than the Supreme Court held that the act of legislature authorizing the issue of these special bonds was illegal, and the whole project had to be abandoned.

It was now necessary to devise some method of obtaining additional water which would not cost more yearly than could be spared and paid for out of the annual revenues of the city.

To meet this condition a system of segregated wells and pumping stations was determined upon, to be constructed as fast as our means would permit.

Up to this time the water obtained from our best well did not exceed ½ million gallons daily and the smallest well produced but little over 100,000 gallons. With the established plan of independent plants scattered at various points about the city, it was highly desirable to produce from each well as great a volume of water as possible and to this end it was decided to make the diameter of each well as large as practicable.

The first well constructed under this plan and finished in 1907, was drilled 1621 feet in depth and has a diameter of 16 inches at the top and seven inches at the bottom, the reduction in size being due to the insertion of liners to shut off caving rock at several points.

This well more than met our expectations as a water producer and furnishes about 1,200,000 gallons daily.

We were still short of water, however, and more and more frequently was it necessary to tide over periods of extreme shortage by pumping raw water direct from Hickory Creek into our mains. In 1910 after experiencing a severe water famine during the summer months, means were obtained to proceed with further well construction. It was decided to attempt to build enough new plants to put our water supply entirely on an artesian basis and cut out all water from Hickory Creek either direct or through the drive wells.

Four new wells were planned and it is to relate some of the troubles experienced in sinking the first of these that this paper is written.

In the design of these wells it was determined to start the bore with a sixteen inch hole and continue down with as little reduction in size as possible. In the location of the wells, the main considerations were, first, to place them at points where the surface of the ground was as low as possible in order to reduce the height of water lift; and, second, to get them widely separated and adjacent to large sized distribution mains and located on cheap property where a pumping plant would not prove a nuisance to the local residents.

The artesian water obtained in Joliet comes principally from two sources, the St. Peters and Potsdam sandstones, which outcroping in northern Wisconsin are found at a depth of about 600 and 1400 feet respectively in Joliet. In the earlier artesian wells of Joliet which penetrated these strata the water pressure was sufficient to produce flowing wells. That condition, however, has passed away and with the constantly increasing number of wells in use the static head of the water is being gradually lowered. In 1880 nearly all wells were flowing; in 1900 no wells in this vicinity were flowing and the static level of the water had receded to about 30 feet Joliet Datum (20 feet below the surface of the main business district). At the present time after five years of operation of our successful 1,200,000 gallon well the static head within 2000 feet of the well has been reduced fully forty feet. While being pumped, the water level in the well is drawn down over 150 feet below the surface of the ground.

Contracts were signed in September, 1910, for the construction of two out of the four new wells to be drilled. The Ohio Drilling Co. of Massilion, Ohio, having been awarded the work. This company, instead of using the customary pole rigging of all well drillers heretofore operating in Joliet, proposed to install cable rigged plants and were sanguine that they could sink each well in 90 days, instead of the usual 8 to 10 month period.

Bids were received for drilling well number one, September 12th, 1910. After some delay in acquiring a site, work was started November 26th with a bit cutting an 18 inch hole. The specifications called for a hole of sufficient diameter to permit the insertion of 14 inch O. D. casing; but the contractor preferred to drill a hole 18 inches instead of 16 inches as contemplated. A McCain mounted machine with a 25 H.P. boiler and engine comprised the drilling plant. The drill stem was 5½ inches in diameter and 30 feet long and the string of tools were made with 3½ x 4½ boxes and pins.

The work started off fairly well and considering the size of the hole being drilled and the delay occurring through a number of minor mishaps we felt good progress was being made when a depth of 200 feet was reached in about 20 days. The best day's record being 30 feet in 24 hours. This depth was through Niagara limestone to the underlying shale formation. It was the intention to reduce the size of the bore below this point to a 12 inch hole, the 14 inch casing being planned to extend only to the 200 foot depth, there, being sealed off to prevent surface water from entering the well.

Difficulty was experienced in getting the string of casing in place. Although it was finally accomplished we found upon testing the well

that there were several crooks in it and that it was out of plumb six inches.

As the deep well pump we had decided to use required a vertical hole at least 150 feet down, the contractor was ordered to straighten the hole. In the meantime, while we were preparing to test the hole the contractor had continued his drilling with a 12 inch bit. At a point about 218 feet below the ground surface he struck oil strongly impregnated with gas and tar—a vile mixture. Suspicion naturally turned to an adjacent gas house some two hundred feet away, as being responsible for this product, and although the well operators insisted the oil was shale rock oil there can be no question that the gas and tar was refuse product of the gas house. To remedy if possible this difficulty, the contractor was ordered to remove the casing already in place, straighten his hole, and extend the large bore and the 14 inch casing down through shale rock to the Trenton limestone, a total depth of about 300 feet.

The removal of the casing proved a task in itself as the string of pipe parted several times and fishing operations were necessary. Twenty-six days elapsed before it was accomplished. The straightening of the hole was then undertaken, first by starting a 20 inch reamer from the top, then using dynamite to knock off some knobs and finally starting again at the top with a 24 inch reamer and continuing down to the 200 foot level. Thirty-five days were required to complete this task and get the 14 inch casing down well into the shale rock.

We now thought the worst of our troubles were over as there was no further sign of oil or gas and the water from the well was fine.

Drilling started again but was soon interrupted by the character of the shale rock above and outside of the casing. As fast as a few feet were drilled, the shale rock under the churning action of the drill and water would slide into the hole like liquid mud and fill up the bore 20 or 30 feet. At this inopportune time a bit came unscrewed, dropped into the soft shale and was driven crossways of the well with the upper end of the bit lodged outside of the well casing which was following down and rested on the bit. Owing to the distance the pipe had followed, together with its weight and the friction of the soft shale against it, pulling the casing could not be considered. All the arts of the well driller were then brought into play and finally with a knife hook the casing was split enough to permit the end of the bit to be hooked into the pipe which was then driven over the bit and the bit fished out. The well casing was then grouted and sealed with Portland cement from top to bottom. Two full months were required in doing all this work. It was May the 12th, 1911, when all the iron, tools, and debris were cleared away and the Trenton limestone reached at a

depth of 325 feet making a total time of nearly six months to reach a depth approximately one-fifth of the total planned depth of the well.

Progress, however, now became quite rapid and through the St. Peters sandstone sometimes fifty feet in a day was accomplished. At a depth of 893 feet on account of soft rock, 100 feet of 10 and 5/8 inch liner had to be inserted but from that point no further reduction in the size was found necessary and with only a few minor mishaps the well was completed through the Potsdam sandstone to a depth of 1570 feet on July 27th, 1911. The contract prices for this work are as follows:

$4.50 per foot for 15" hole (or larger)
3.40 per foot for 12" hole
3.25 per foot for 10 5/8" hole.

Unfortunately for us our troubles were not over with the completion of the drilling. Haste was made to get in engine and pump house foundations and before the walls of the building were completed the engines were set in place and put in motion.

It was a memorable day but sad, for instead of a million gallons of the purest water wherewith to slake the parched throats of our citizens, there issued from the pumps a mixture of the blackest, oiliest, most nauseating compound it was ever my misfortune to witness.

Continuous pumping for several weeks did but little to remedy the character of the product and it was finally decided to remove the pumps and put in another string of inner casing, about 600 feet long, down to the St. Peters sandstone. Fortunately the well bore was amply large to permit this expedient and so, with a thoroughly tested patent packer on the end of the string of casing, this pipe was inserted in the well and the packer put in operation just above the junction of the St. Peters sandstone with the Trenton limestone. There it held so tightly that the entire string of 600 feet of casing resting upon it did not budge it a particle. The pumps were again reset and put in motion. For fifteen minutes the water came pure and sparkling and we thought we had the trouble beaten, but our exultation was short lived for soon great globes of oil and tar again appeared and although under pumping these were materially reduced, enough still continued to unfit the water for use.

As a last resort it was then determined to extend the casing still deeper, to the top of the liner, making a total length of casing and liner nearly 900 feet long. In putting this string in place, when all but three lengths of pipe had been inserted, a jar on the windlass caused the thread of the last pipe to strip and the string of pipe dropped about 60 feet to the top of the liner. After an investigation, which as far as could be determined without taking the entire casing

out, revealed no damage, the last three sections were added and the pumps started again. A very material improvement of the water was apparent but it still seemed to be more or less impregnated with enough gas to render it obnoxious and we are now removing the entire 900 feet of casing to make certain of the integrity of the pipe.

In the construction of wells number two and three, the difficulties developing were more or less a repetition of the troubles on well number one, except that no oil was encountered. Work on number two commenced May 14th, 1911, and on July 17th, 730 feet of depth had been secured. At this point, however, which is in the St. Peters sandstone, the character of the rock, which ordinarily gives no trouble from caving, changed so materially that it acted under the drill like quicksand. All sorts of expedients were resorted to, in making progress through this stratum, but with a reduction in the size of the hole down to seven inches over seven months elapsed before we reached the harder rock at a depth of a thousand feet. At the present time, ten months after starting, the depth of the well is about 1200 feet.

Work on well number three commenced in September, 1911, and trouble immediately started with caving rock and quicksand. The only special feature which has so far developed with this well is the presence of a fault or fissure in the rock which causes the drill to continually work off to one side, giving great trouble in keeping the well vertical and in keeping the drill from becoming fast in the rock. Six months work on this well has been productive of a hole about 800 feet in depth. Well number four has not yet been started.

Our experience in Joliet in constructing this series of wells and the wells drilled in the last twenty years is interesting principally because of the obstacles which have had to be overcome. No two wells have acted precisely the same. While the strata are identical, the variation in thickness of each stratum, the changing character of the rock from hard to soft, from quicksand to flint, the possibilities of striking oil or salt water, and the variable water productiveness of the St. Peters and Potsdam deposits, have made each well a problem of extreme uncertainty. Large bore wells have proven expensive and difficult to drill but are warranted by the largely increased yield of water they produce.

With the probable completion and operation of all four wells during the present year the pumpage of four or five million gallons daily from these wells, a marked reduction in the water level in the ground is to be expected and will probably have an important bearing on the question of further development of our water supply from artesian wells.

NOTE—For discussion see page 243.

SANITARY SURVEY OF THE MISSISSIPPI RIVER AT MOLINE.

BY EDWARD BARTOW.*

As a result of agitation concerning the water supply of Moline, a commission of business men was appointed to investigate conditions. This commission submitted its report May 6th, 1911. From the analyses of the water taken from different points in the river, they reported that steps should be taken at once to obtain a better supply of water, and recommended that the intake be removed to a point above Campbells Island. The recommendation was based on one analysis made in May of the water above Campbells Island with 1300 bacteria per cubic centimeter compared with three analyses of water from the channel opposite the city made on January 9th, with 7000 bacteria, on January 10th with 35000 bacteria, February 4th with 292000. The anaylses had been made by different analysts. The time between the collection and the analysis of the samples had differed.

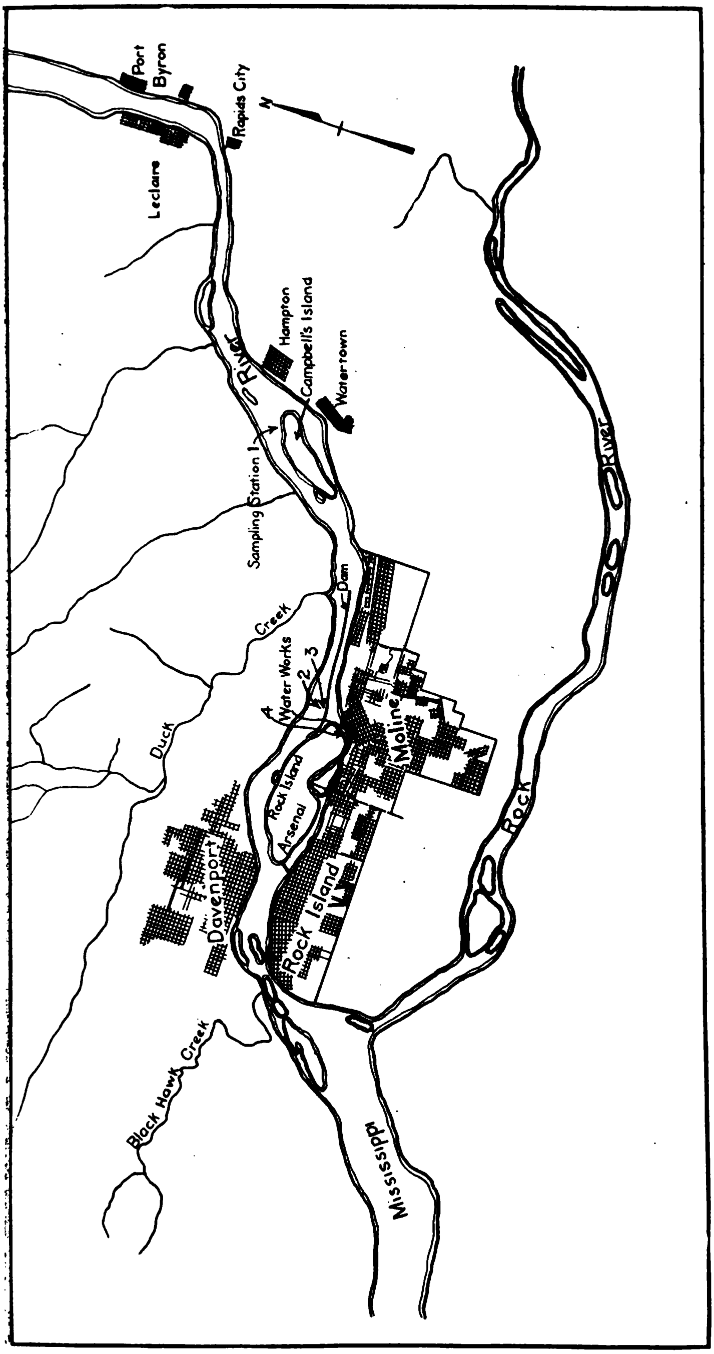
A change of the intake to Campbells Island would mean the expenditure of a large sum of money, probably $500,000.

Mayor M. R. Carlson thought it ill advised to go into the matter without a more thorough and efficient chemical and bacteriological test.

On May 11th, 1911, the Mayor was authorized by the Commission to make the necessary tests. Mr. Lewis I. Birdsall, Chemist in charge of the Water Purification Plant at Rock Island, was engaged, and the co-operation of the State Water Survey was requested.

In response to this request the State Water Survey has conducted a series of analyses to determine the relative character of the Mississippi river water at three points—viz. at a point above Campbells Island (see map), at a point in the channel at the water works

*Director Illinois State Water Survey.



Map Showing Sampling in Mississippi River at Moline.

TABLE OF ANALYSES TO ACCOMPANY REPORT OF THE INVESTIGATION OF THE CHARACTER OF THE MISSISSIPPI RIVER WATER AT MOLINE, JULY, 1911, TO DECEMBER, 1911.

Date.	No.	Turbidity	Color	Odor	Residue		Chlorine	O. Cons.		Nitrogen as						Alkalinity	Bacteria per c.c.	Gas Formers			Indol.	Remarks
					Total	Dissolved		Total	Dissolved	Free Am. Tot.	Free Am. Dis.	Alb. Am. Tot.	Alb. Am. Dis.	NO_2	NO_3			10 c.c.	1.0 c.c.	0.1 c.c.		
MISSISSIPPI RIVER ABOVE CAMPBELL'S ISLAND. (1)																						
July 9........	22128	250	30	1E	208	......	2.	7.6	......	.104	......	254	......	.000	.560	126	1100	1—	1+1—	1+1—	+	
Aug. 15....	22314	1500	40	1E	960	150	4.	17.2	5.0	.160	......	960	.128	.045	.755	82	28600	1+	2+	2+	+	
Sept. 12....	22424	90	45	1E	243	......	1.	8.1	......	.048	......	.344	......	.014	.440	138	13000	1+	1+1—	2+	+	
Oct. 16......	22539	300	170	1E	440	110	.8	18.2	15.9	.096	......	.576	......	.006	.320	46	2700	1+	2+	1? 1—	+	
Average 4 mo.		535	71		463		2.0	12.8		.102		.533	.	.016	.519	98	11350	+	+	+	+	
CHANNEL OF RIVER NEAR INTAKE—150 FEET OUT. (2)																						
July 9........	22129	280	40	1E	253	......	2.	7.6	......	.038	......	.366	......	.000	.320	130	900	1+	2+	1+1?	+	42 hrs.
Aug. 15....	22315	1500	120	1E	963	145	3.	17.1	6.2	.200	......	.980	.200	.060	.580	80	20000	1+	2+	2+	+	
Average 2 mo.		890	80		608		2.5	12.4		.119		673		.030	.450	105	10450	+	+	+	+	
CHANNEL AT INTAKE. (3)																						
July 9........	22131	330	40	2E	258	......	2.0	7.5	......	.088	......	.272	......	.000	.240	128	900	1—	2+	2+	+	42 hrs.
Aug. 15....	22316	1500	100	1E	904	153	3.	17.5	5.4	.200	......	.980	.152	.060	.580	80	25000	1+	2+	1+1—	+	
Sept. 12....	22420	100	40	1E	265	......	3.	7.9	......	.056	......	362	......	.014	.240	140	55000	1+	1+1?	1+1—	+	
Oct. 16......	22540	155	155	1E	265	129	.6	17.7	16.3	.072	......	.400	......	.004	.240	48	1300	1+	2+	2?	+	
Nov. 14....	22677	250	100	1E	407	163	1.2	17.0	9.0	.088	.144	.392	.224	.004	.920	104	15000	1+	2+	2+	+	
Average 2 mo.		915	70		581		2.5	12.5		.144		626		.030	.410	104	17000	+	+	+	+	
Average 4 mo.		521	84		423		2.2	12.7		.104		.503		.019	.325	99	20550	+	+	+	+	
Average 5 mo.		467	87		420		2.0	13.5		.101		.481		.016	.444	100	19440	+	+	+	+	
POOL NEAR INTAKE. (4)																						
July 9........	22131	270	30	1E	232	......	2.0	7.0	......	.044	......	.238	......	.000	.280	128	300	1+	2+	1+1—	+	42 hrs.
Aug. 15....	22317	720	120	1E	440	182	3.0	12.1	5.6	.240	......	.480	.200	.068	.570	82	170000	1+	2+	1+1—	+	
Sept. 12....	22421	125	40	2E	317	......	2.0	7.6	......	.052	......	.388	......	.012	.320	134	22000	1+	2+	2+	+	West side
Sept. 12....	22422	130	45	1E	282	......	1.0	8.2	......	.062	......	.426	......	.015	.360	134	12500	1+	2+	1+1—	+	East side
Oct. 16......	22541	140	170	1E	242	116	1.6	17.5	16.2	.104	......	.544	.006	.006	.120	46	1200	1?	2+	1+1—	+	West side
Oct. 16......	22542	140	170	1E	233	100	1.2	16.5	15.5	.056	......	.376	......	.002	.480	46	1	1?	1+	1? 1—	+	East side
Nov. 14....	22675	240	110	1E	407	180	1.4	16.6	8.8	.088	.184	.400	.232	.002	.520	104	14000	1+	2+	2+	+	West side
Nov. 14....	22678	240	110	1E	423	167	1.4	16.9	9.0	.200	.128	.394	.248	.002	1.040	102	12000	1+	2+	1+1—	+	East side
Average 5 mo.		300	94		325		1.9	12.2		.113		.396		.018	.454	99	40250	+	+	+	+	

INTAKE WELL. (5)

Oct. 16......	22543	150	180	1E	245	98	.8	17.7	15.6	.112	......	.448	......	.002	.280	48	700	1?	2+	2+	+	
Nov. 14....	22674	230	100	1E	385	158	1.0	16.6	9.2	.096	.184	.384	.256	.002	.520	104	9600	1+	2+	1+1—	+	
Average 2 mo.		190	140		315	128	.9	17.2	12.4	.104		.416		.002	.400	76	5150	+	+	+	+	

FILTERED WATER FROM TAP IN OFFICE. (6)

July 9........	22132	3	15	1E	200	......	3.0	3.9	......	.016	......	.194	......	.000	.200	114	12	1+	2—	2—	+	
Aug. 15....	22318	0	0	0	175	......	4.0	1.8	......	.148	......	.110	......	.050	.510	72	350	1—	2—	2—	—	
Sept. 12....	22423	1	10	1E	207	......	3.0	4.1	......	.020	......	.160	......	.006	.320	122	75	1+	1+1—	2—	+	
Oct. 16......	22544	2	8	1E	147	......	2.6	3.5	......	.080	......	.384	......	.005	.440	30	10	1+	2—	2—	+	
Nov. 14....	22676	20	20	1E	179	......	2.4	3.3	......	.064	......	.120	......	.000	.560	72	200	1—	1+1—	2—	—	
Average 5 mo.		5	11		192		3.0	3.1		.066		.194		.012	.406	82	129	+	—	—	+	

COMPARISON OF WATER FROM CAMPBELL'S ISLAND (1) WITH WATER FROM CHANNEL AT INTAKE. (3). (7)

		535	71		463	......	2.0	12.8	......	.102	......	.533	......	.016	.519	98	11350	3+1—	6+2—	5+2—	4+	Campbells Is.
		521	84		423		2.2	12.7		.104		.503		.019	.325	99	20550	3+1—	7+1?	4+2—	4+	Channel

COMPARISON OF WATER FROM CHANNEL 150 FT. FROM INTAKE (2) WITH WATER FROM CHANNEL AT INTAKE (3). (8)

		890	80		608		2.5	12.4		.119		.673		.030	.450	105	10450	2+	4+	3+1?	2+	150 out
		915	70		581		2.5	12.5		.144		.626		.030	.410	104	17000	1+1—	4+	3+1—	2+	Near intake

COMPARISON OF WATER FROM CHANNEL AT INTAKE (3) WITH WATER FROM POOL NEAR POOL INTAKE (4) (9)

		467	87		420		2.0	13.5		.101		.481		.016	.444	100	19440	4+1—	9+1?	6+2—	5+	Near intake
		300	94		325		1.9	12.2		.113		.396		.018	.454	99	40250	6+2?	15+	9+6—	8+	Pool 8 anal.

COMPARISON OF WATER FROM WEST AND EAST SIDES OF POOL (4). (10)

		170	108		313		1.2	13.9		.106		.399		.006	.627	94	8200	2+1?	5+1?	2+3—	3+	East side
		168	107		323		1.7	13.9		.081		.444		.007	.320	95	12400	2+1?	6+	5+1—	3+	West side

COMPARISON OF WATER FROM CHANNEL AT INTAKE (3) WITH TAP WATER—FILTERED (6) (11) Aver. 5 mo.

		467	87		420	......	2.0	13.5		.101		.481		.016	.444	100	19440	4+1—	9+1?	6+2—	5+	At intake
		5	11		192		3.0	3.1		.066		.194		.012	.406	82	129	3+2—	2+8—	10—	3+	Tap water
Reduction		462	76		228			10.4		.035		.287		.004	.038	18	19310					
% reduction		98.9	87.3		54.3			77.0		34.6		59.7		25.0	8.5	18.0	99.3					

intake, and at a point in the pool near the pool intake. With these have been made analyses of the filtered water to determine the efficiency of the present filter plant. All samples have been taken by the Director of the State Water Survey accompanied by Mr. Lewis I. Birdsall, Commissioner Jahns, and in some cases by Mayor Carlson and Commisioner Anderson. At the same time and same places samples of water were collected by Mr. Birdsall and his report confirms the findings reported in this paper.

Four analyses were made of water collected above Campbells Island (1).* Comparing these with four analyses taken on the same dates from the channel at intake (3) we find (7) that the water from Campbells Island is of practically the same character as the water from the channel. While the average number of bacteria from the channel is higher (20,550 and 11,350); in three of the four comparisons made, there were fewer bacteria in the channel at the intake than in the river at Campbells Island. In my opinion, these results show conclusively that the city of Moline would not be warranted in building a new intake above Campbells Island.

On two occasions, July and August, samples were taken from points approximately 150 feet out in the channel from the present channel intake. Comparing these results (2) with the results of the analyses of the water at intake (3) collected at the same time, July and August, it is seen (8) that no advantage would be gained by the extension of the intake.

A comparison of the water from the channel at the intake (3) with the water from the pool near the pool intake (4) shows the water from the pool to be a better water from the standpoint of turbidity, residue on evaporation, oxygen consumed, and nitrogen as albuminoid ammonia. The average number of bacteria are much higher in the sample from the pool; but an inspection of the individual analyses shows that in three of the five comparisons the number of bacteria from the pool was lower than from the channel; the higher average being accounted for by finding 170,000 bacteria in the pool intake on August 15th. The tests for gas formers were positive in all of the 10 cc. and 1 cc. samples, and in the majority of the 0.1 cc. samples, showing that the amount of purification would be practically equal whether the water were taken from the channel or the pool. Samples of water taken from the channel at intake in October and November (3) compared with samples of water taken from the intake well (5) on the same dates show a little better condition in the water in the intake well than that collected directly from the pool,

*Figures in parentheses refer to divisions of the appended table.

though the difference is very slight. This comparison is of interest since it shows the similarity between the surface and deeper water.

A comparison of the water from the west and east side of the pool (4) (10) shows very slight differences. It would be difficult to choose between the two. These samples were taken, in each case, at least 100 feet from the shore.

The efficiency of the filtration plant is illustrated by a comparison of the water from the channel at intake (3) with the analyses of the water taken from the tap at the pumping station (6). As seen in (11) there is a very satisfactory reduction in the turbidity, color, residue, oxygen consumed, albuminoid ammonia, and in the number of bacteria per cubic centimeter. The bacterial examination of the filtered water has shown the water to be safe, and this comparison shows that it is practicable to filter the Mississippi river water as now obtained opposite the present pumping station in Moline. In addition to the conclusion already drawn, the results of observations of the situation at Moline suggest two things which will be of assistance in furnishing the city of Moline with a pure drinking water.

First, Regular, daily, chemical and bacterial control of the plant. This will indicate at all times the efficiency of the filter plant and will enable those in charge to use the minimum amount of chemicals.

Second, The installation of meters to tend to check waste of water. If the water is not wasted, the present filter capacity will be sufficient to supply the city with pure water for several years to come.

DISCUSSION.

Hills: Any discharge below the Island and above the intake?

Bartow: Very little. The alarming features were sewers from summer cottages along the Island which are occupied only during the summer months.

Jennings: I would like to ask Dr. Bartow about the character of the sand in the Moline filters, which has enabled them to get such a high percentage removal of bacteria. Is the sand incrusted?

Bartow: There was incrustation on the sand grains when Iron and Lime were used. Alum has been used, I think I am right in saying, almost two years and they have been using Hypo for the same time.

Jennings: Is this the same sand that was used in the summer?

Jahns: That was used and replaced.

Gerber: What is the relative position of the intake at Davenport with reference to the intake at Rock Island?

Bartow: The Davenport intake is in the channel on the west side of the river. It is more liable to pollution than the channel intake of the Moline water works. It is liable to pollution from the town of Bettendorf and from drainage from a creek above Davenport. The Rock Island intake is on the east side of the main channel.

Monfort: I have noticed in one case a turbidity on November 14th in the filtered water of something like 20. Was there any unusual trouble at just that time.

Bartow: I am afraid I cannot answer that question. I cannot remember the specific case.

Monfort: The reason why I asked was because just about that time there should have been trouble and I neglected to notice what it was for the channel intake and the other intakes on raw water.

COLOR IN MISSISSIPPI RIVER AT SAINT LOUIS.

BY W. F. MONFORT.*

The first water collected from a shingle roof after a period of drouth is usually turbid. Its appearance is brownish or black—"apparent color," as determined from surface observation. If it be passed through filter paper and the suspended matter removed, it shows a more or less deep brown, or red-brown, or yellowish tint as seen by transmitted light; this is its "true color."

If for shingles we substitute piles of sawdust, water which runs over and through the piles will show, similarly, a color varying in shade and intensity according to the kind of wood which has furnished the refuse, and the extent to which cell contents have been altered by enzymes and leached by previous rains. Hollow stumps often hold water deeply browned by decaying tissues.

Water standing in the 5000 to 6000 lakes and innumerable swamps in the headwaters of Upper Mississippi River, exposed to more or less decomposed vegetable matter—bark, woody tissue, leaves, sawdust, marsh grasses, fallen needles and cones of pine and cedar, hemlock and tamarack—acquires a color which is very deep. The first heavy precipitation in this region flushes out the colored water from these steeping basins into rising streams and into the main river.

As representative of the character of the watershed of Upper Mississippi in its entirety, attention is called to three areas in Wisconsin. Chippewa River Drainage system has its source in more than a hundred lakes, large and small, with many connecting swamps, lying in the northwestern part of Wisconsin, near the Michigan boundary, and only 20 miles from Lake Superior. * * * The drainage basin comprises about 9573 square miles, of which over 6000 square miles include the most unsettled region of northern Wisconsin. * * * The wooded regions include very large areas of cedar and tamarack swamps. * * * This drainage basin contains the richest forests of both hard and soft woods still standing in Wisconsin. Although lumbering has been carried on actively for many years, considerable pine timber still remains chiefly at the upper head waters, but it is fast disappearing. The upper half of the

*Chemist, Water Department, Saint Louis.

drainage basin may be considered forested.* Chippewa River joins the Mississippi at the foot of Lake Pepin.

The drainage basin of Wisconsin River, except for a few square miles, lies almost wholly within the State of Wisconsin. The total drainage area is about 12,280 square miles. The northern part is covered with innumerable lakes and swamps, which tend to make the flow of the stream uniform. The dense growth of pine which covered the upper part of the drainage basin of Wisconsin River has nearly all been cut off, and a thick growth of brush and second growth timber has taken its place; large areas have been brought under cultivation. In some places this second-growth has been burned over, leaving almost impenetrable thickets of brush and dead timber. The mean annual rainfall on the headwaters is about 31 inches; at the lower part of the basin the rainfall is about 34 inches. The stream is used extensively for logging, but the greater part of the large timber has been cut off and lumbering is decreasing, although considerable pulp wood is being run in the river.

Black River basin lies west of the central part of the State of Wisconsin; and has a total area of about 2272 square miles. The timber on the drainage basin has all been cut off, and the river is not used for running logs. But few lakes occur. Black River joins the Mississippi at LaCrosse.

These three rivers with their tributaries drain a combined area of more than 23,000 square miles in a region whose mean annual rainfall is from 30 to 34 inches; they are representative of numerous rivers of the Upper Mississippi drainage area at head waters.

Illinois River drainage basin is wholly in prairie region, under close cultivation, and unusually fertile, with a mean annual rainfall of 30 to 40 inches. While the headwaters at Missouri River are in a forested basin, the main stream flows through a country almost devoid of forests, with an annual average precipitation of less than 20 inches. Neither Illinois nor Missouri River drainage areas abound in swamps.

The discharges of the three rivers which unite above Saint Louis, therefore, differ no less in forestation, in extent of lumber operations, and in color of water discharged than in mineralization. When forests on the drainage basins at the head of the Mississippi are exhausted —should this ever occur—we may expect the color of Upper Mississippi water to be reduced; but because of extensive swamp lands

*U. S. G. S. Water Supply Paper 265.

which will probably persist, color can hardly become a negligible quantity as it is on the Ohio, the Missouri, and the Illinois.

It is apparent, that at present, unequal distribution of spring and fall rains—or rains which at any time of year follow protracted drouth—must result in a disturbance of the balance represented by "mean annual discharge" of the rivers under consideration, with corresponding change in color of water entering the Saint Louis intake. It is said that the mean annual discharge of Upper Mississippi at Hannibal is 125,000 second feet; of Missouri River at its mouth, 100,000 second feet. However, in 1906-1907 Upper Mississippi was rated at 77,000 second feet; Missouri River at 97,000 second feet, while Illinois River had an average discharge of but 28,000 cubic feet per second. There is evidence that these averages cover very significant fluctuations in the relative weight of discharge during the specific period mentioned.

From the point of view of river navigation, it is desirable that precipitation be so distributed that a good stage of water prevails at all times. Areas of low barometric pressure should so distribute their precipitation that Missouri River with its steeper gradient may discharge its excess before the run-off from Upper Mississippi reaches Grafton, while Illinois rainfall with an increment from Chicago drainage canal maintains an equable flow. This may be the case and the resulting stage quite satisfactory, while the quality of water entering the intake at St. Louis, derived from Missouri River, or from a blending of Upper Mississippi River with Missouri River or with Illinois River water, presents extreme difficulties in treatment as a potable water. For, usually, Missouri River imparts its turbid character to water flowing down the west shore of the Mississippi, while a more or less complete mixture of Upper Mississippi water with Illinois River water occupies the eastern side of the channel. The line of demarcation persists some distance below the Chain of Rocks intake, disappearing about 7 miles below, at Merchants' Bridge.

In September, 1911, there was an unusual precipitation in Northern Illinois and Wisconsin. At Monmouth, Ill., 20 inches fell in the month of September—a half year's rainfall. The mean for the State of Illinois was 8.84 inches, an excess of more than 5 inches above the normal. This was followed in October by 2.9 inches average in Illinois—an excess precipitation of 0.6 inches. As a result Illinois River was abundantly full both months.

These general rains in September continued into early October, brought disaster in the Black River Valley in Wisconsin, with the failure of dykes at Hatfield and Dells Reservoirs above LaCrosse,

October 6, releasing almost 700,000,000 gallons of stored water after a torrent had been flowing all day 10 to 12 feet deep over a spillway 490 feet long. For the twenty-four hours ending at 7 A. M., October 6, precipitation at St. Paul was 3.6 inches, and at Madison, Wis., 1.72 inches.

The volume of water released at Hatfield and Dells Reservoirs was small, compared with the total run-off from Upper Mississippi Drainage Basin, or even with that portion of the watershed lying in Wisconsin. A precipitation of one inch over the 1264 square miles of Black River Basin would amount to 2,936 million cubic feet; in the Chippewa drainage area of 9,573 square miles, one inch precipitation is equivalent to 22,240 million cubic feet; while in Wisconsin River drainage area of 12,280 square miles, one inch rainfall is equivalent to more than 28,528 million cubic feet. There was thus in the State of Wisconsin alone on October 6 a rainfall on these three

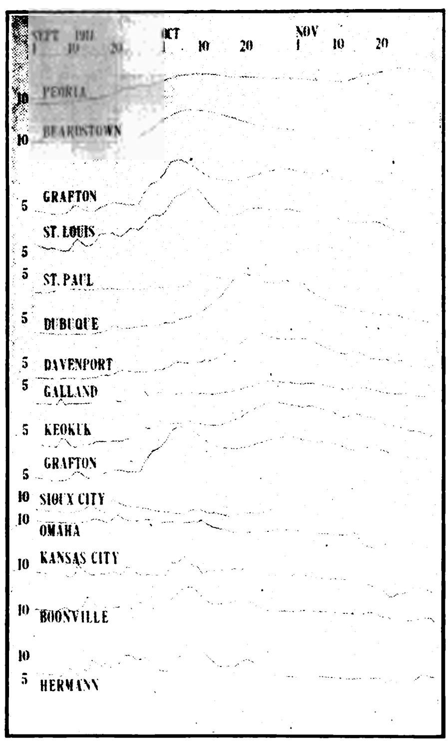


Diagram 1. Stages of Illinois, Mississippi and Missouri Rivers.

drainage basins amounting to probably more than 100,000 million cubic feet, assuming the average precipitation at 2 inches.

The result of heavy rainfall in September and October is shown in the first diagram, wherein are platted the stages of the three rivers (Illinois, Mississippi, and Missouri).

1. A flood stage was maintained in the Illinois River, at Beardstown and Peoria, into November. At Grafton on the Mississippi the stage is affected by inflow from Missouri River and by discharge of the Illinois.

2. General rains caused the Missouri River to rise in September and early October; on October 5th is shown the effect of the passage of the same storm, which spent itself the following day over the headwaters of Upper Mississippi River. Then followed a steady decrease in discharge of Missouri River; as the collected water flowed off rapidly because of the gradient. From Omaha to St. Louis the flow of water requires 11 to 12 days.

3. On October 6, came the beginning of a rapid rise at St. Paul and the Hatfield disaster.

4. The crest of the wave reached Dubuque on the 18th-20th; Davenport on the 21st-23d, passing on the 31st, with a color at Rock Island, October 17, of 130; and up to 140, November 7; (incomplete records at Moline show a color of 120 on the 18th); the crest of wave and color was at Quincy on the 25th to the 27th. At Saint Louis the crest is flattened; the color ranged from 90 to 120 from October 26th until November 10.

The second diagram compares river stages at points nearest above St. Louis for October and November.

1. Illinois River (Beardstown gage), pushing out strongly, first affects Grafton and St. Louis.

2. Missouri River (Hermann gage) is shown almost parallel with Grafton and St. Louis for the first 8 days, then declining rapidly until the 16th; rising a few days slightly; then declining to the end of the month.

3. Mississippi River (Keokuk gage readings) fluctuates slightly in the early part of the month, then rises abruptly to the 25th and maintains a high stage to the end of October and late into November. Mississippi River is the predominant factor toward the end of the month and well through November. In general, when the gage reading at Keokuk exceeds that at Hermann, Upper Mississippi is dominant. If Illinois River is in flood the line of demarcation between the

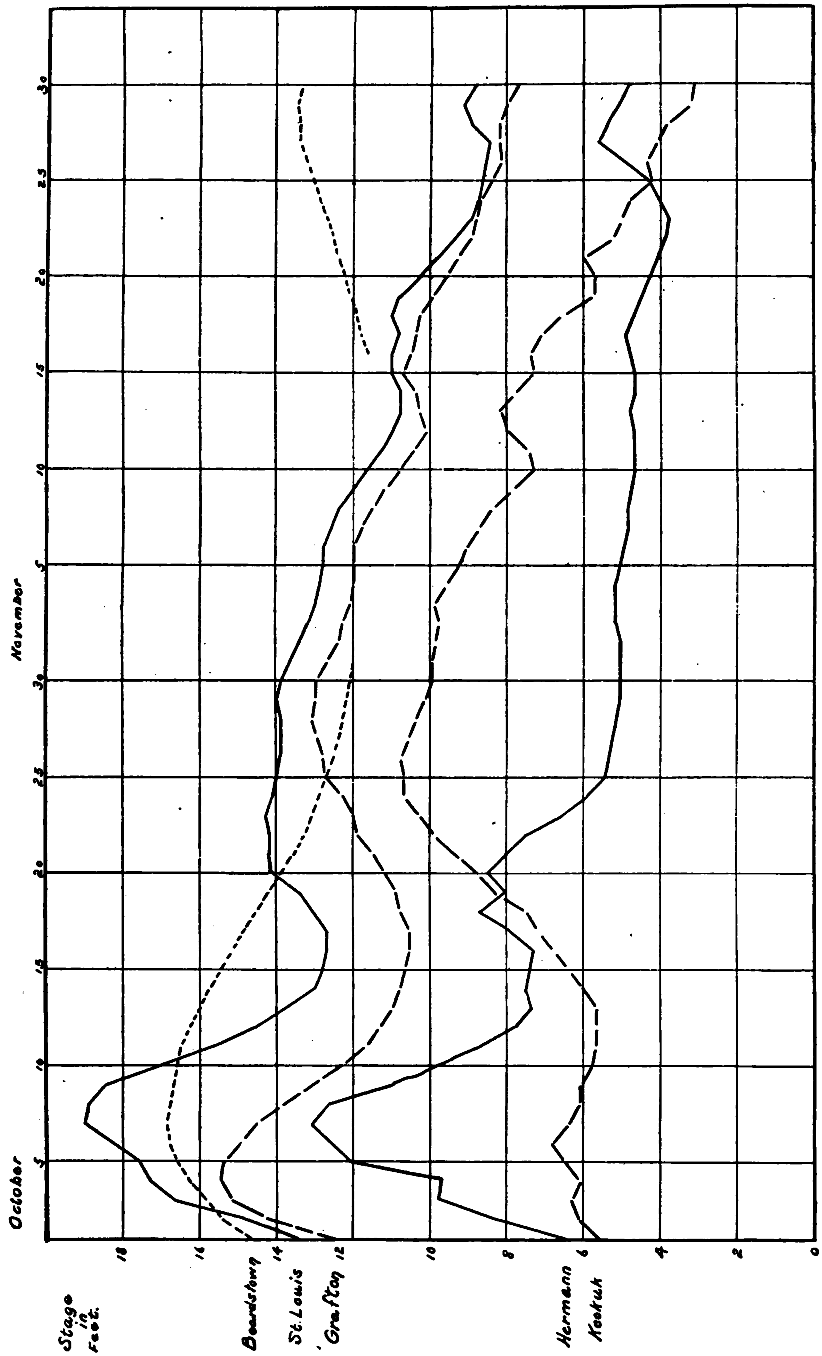


Diagram 2. Comparison of Stages of Mississippi, Missouri and Illinois Rivers.

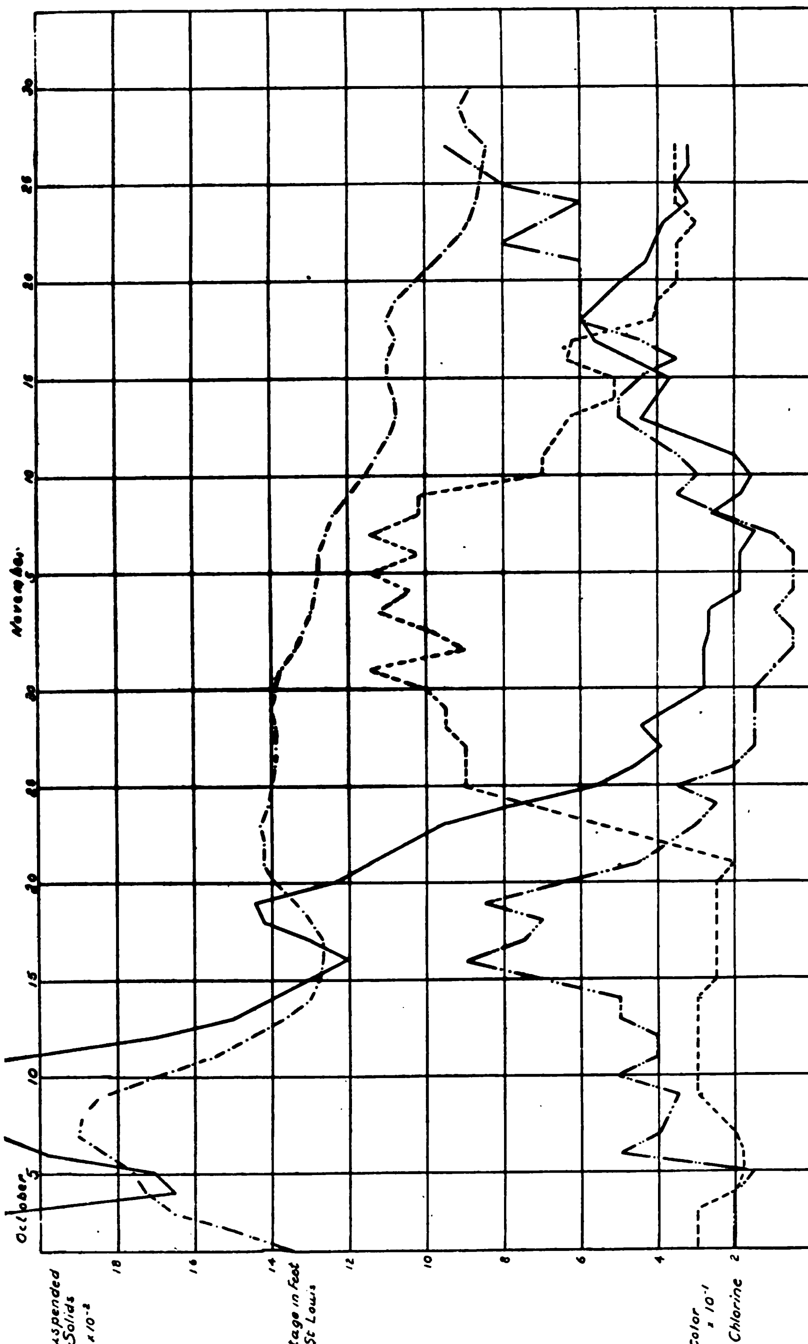


Diagram 3. Comparison of Chemical and Physical Data with the Stage of Mississippi River.

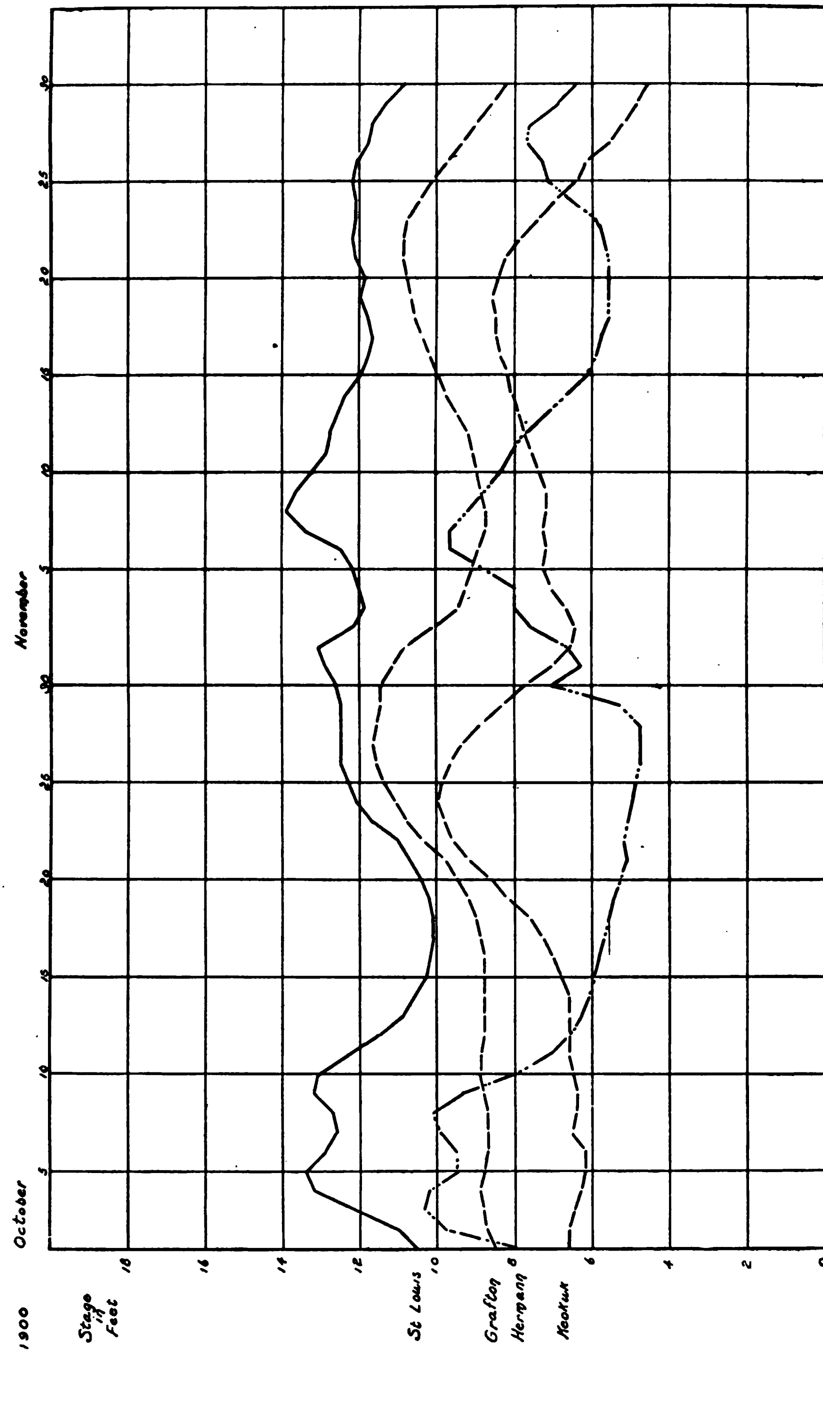


Diagram 4. Comparison of Stages of Mississippi River.

muddy water of Missouri River and the less turbid waters of the upper rivers will fall west of the St. Louis intake.

It will be observed that Keokuk and Hermann curves cross only on the 25th; and that prior to this date, Mississippi River at St. Louis follows the fluctuations of the stage at Keokuk.

The third diagram compares some chemical and physical data for St. Louis, with the stage of the river for October and November.

1. Suspended solids are highest with Missouri's maximum.
2. Chlorine is inversely proportional to dilution—inverse to stage.
3. Color varies inversely with stage so long as Missouri River is rising; then rises abruptly with the advent of predominant Upper Mississippi and Illinois River waters.
4. Normal conditions are reasserted when Keokuk stage falls below Hermann stage late in November.
5. Maximum color from 90 to 120 persists at St. Louis from October 26 to November 10, sixteen consecutive days.

Color determinations toward the Illinois shore east of the intake gave uniform results during this period, indicating that practically complete blending of Upper Mississippi and Illinois waters had taken place in the period of flow below Grafton, where the Illinois enters the main river.

At the time of maximum color, discharge of Upper Mississippi River was approximately 150,000 second feet; Illinois River, 25,000 second feet; Missouri River between 30,000 and 38,000 cubic feet per second. The result was that muddy Missouri River water occupied a small, shallow, restricted strip down the west bank of the river, about 1200 feet wide, while the rest of the bed and channel was occupied by a coffee colored liquid (true and apparent color) representing almost four-fifths of the combined discharge of the three rivers. The intake tower of St. Louis water works was for days completely surrounded by the deeply colored flood, which was displaced only after rainfall on Missouri drainage area had increased the relative weight of that discharge.

An earlier occurence of similar conditions was in October, 1900. The dates and duration of the color of 64 in Mississippi water at the intake are not given; but it is stated by Dr. Teichmann that there was a "greenish color impossible to remove with house filters" then depended upon by consumers in the city. The fourth diagram shows a condition prevailing twice (in October and November) when Missouri River was overshadowed; the period was longer in October. Weather records of that time show scant rains in central Mississippi Valley and excessive precipitation in the northern section (2.8 inches excess in Dakota) in October.

Determinations made in 1901 by Dr. Teichmann, at that time City Chemist, gave an average for October in Missouri River at Bellefontaine of 14 parts; Mississippi River at Grafton, a mixture of Illinois and Mississippi River waters, 32 parts; and at St. Louis intake, 16 parts of the platinum scale. (

No later records of color determination are available for St. Louis until 1906, since which time from 1 to 3 determinations have been made daily. Our records show on April 1 to 4 a color of 100 to 120, with river and precipitation records indicating conditions essentially like those of the past year. This occurence differs from that of 1911 principally in duration. A color of 70 was observed in November and in December, 1906.

In 1907 in the first four months of the year and in October the color of water at the intake reached 60 to 70 parts per million.

In 1908, at the close of February and the beginning of March, a color of 110 was observed; while in April, May, and June, color ranging from 50 to 60 is recorded.

The following years, 1908 and 1909, show no color above 40 parts per million.

It is interesting to note in the records of the filter plant at Rock Island, Ill., June 1911 (Engineering Record, Dec. 9), that an average color of 75 was maintained, ranging from 60 to 120. At this time St. Louis was in a fair way to have a minor run of trouble but for the maintenance of balance in the discharge of the three component rivers. Fortunately, however, the muddy water of the Missouri was in sufficient volume to hold the color of the water entering our intake to 40 or less during this period. For 16 consecutive days in October-November, 1911, as recorded above, the color of water at our intake was between 90 and 120 parts per million on the platinum scale.

In all the earlier work at St. Louis, in connection with the plan of treatment selected or developed, color removal was not considered. This may have been because color determinations were not made at Quincy when the pioneer work on iron and lime treatment was done. The fact that high color had occured at times in the Chain of Rocks supply was commented upon in the "Report on the Water Supply of the City of St. Louis by the Commission of Hydraulic Engineers" in 1902, but their argument regarding it was directed rather toward the cost of alum treatment for its removal. Most of the discussion under the topic of color in the majority report is taken up with proof that color is a measure of albuminoid ammonia.

Insufficient data prevented adequate consideration of the matter in 1902 and in the period prior to the Worlds Fair in 1903-1904.

From data here presented, and much more available, it appears that color reduction is frequently a more or less serious problem not only in cities on the Upper Mississippi, but even below the confluence of the eastern and western rivers with the northern one, which must be taken into account in any plan for treatment adapted to all conditions of such a variable water as the St. Louis supply.

DISCUSSION.

Ely: We have this same trouble at Danville. I would like to ask Mr. Monfort how he is able to handle it.

Monfort: It was possible through this period, using lime and iron, to reduce the color about two-thirds; that is, to a color of about 35 parts per million.

Ely: How many grains of iron did you use?

Monfort: At this time we were using 4½ grains of lime and 3½ grains of iron sulphate. With alum it could have been cut down to 20 parts per million using 5½ grains. It seems that the alum treatment is exactly what is needed for that quality of water.

SOME INTERESTING OBSERVATIONS ON THE DISINFECTION OF LAKE WATER WITH CALCIUM HYPOCHLORITE.

BY DR. ARTHUR LEDERER* AND FRANK BACHMANN.†

Ever since water was recognized as an important carrier of disease, the endeavor of sanitarians has been to make it safe for consumption. Guided by thorough bacterial research, and practical experiments by technical men, we are now in a much better position to appreciate the difficulties which have been overcome, and the questions still awaiting solution. As one would reasonably expect, the water problem has received the greatest attention. Until the last few years the study of sewage disposal was largely neglected, although the intimate relation of the problems has been recognized for a long time.

It is not surprising that Europe has been the leader in the protection of water supplies, but the congestion of the population abroad, and the long established centers of learning, accounts for this. Filtration of water supplies and emergency disinfection of sewages had been practiced there long before these protective measures were introduced in this country. How rapidly the filtration of water supplies in the U. S. has increased can be judged from figures stated by Geo. A. Johnson.[1] In 1890, less than 200,000 people were supplied with filtered water, in 1900, 1,860,000 and at present (1911), approximately 8,000,000. However, it is noteworthy that the protection thus afforded has not been altogether a voluntary prophylactic measure, but in most cases was forced upon the population by a heavy toll of death from typhoid fever. Approximately 35,000 people die annually in the U. S. from this disease.

It is said that the introduction of filtration has reduced the

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[1]Hypochlorite Treatment of Public Water Supplies. Eng. Record, 1910, p. 321.

typhoid fever rate by about 75%. The relation of an improved water supply to the mortality from other diseases in the U. S. can only be deduced imperfectly on account of the unsatisfactory methods of making death reports. In 1903 Hiram F. Mills, of Lawrence, Mass., and A. A. Reincke, of Hamburg, noticed a distinct decline in the general death rate of those two cities, after the introduction of a pure water supply. Sedgwick and MacNutt[2] concluded from a thorough study of the death rate statistics of Lawrence, Lowell, Albany, Watertown, Binghamton and Hamburg, that death from gastro-intestinal disorders and tuberculosis are distinctly reduced, while pneumonia, bronchitis and other infections are apparently diminished at the same time.

Allen Hazen stated in 1904, before the international Engineering Congress, at St. Louis, that the examination of the death rate of certain cities, which had improved their water supply, showed that for each death from typhoid fever prevented, two or three deaths from other causes are avoided. The reason for this phenomenon is not clear at present, and suggests a fruitful field for medical research. In a filter plant, ordinarily a bacterial reduction of 95 to 99% may be obtained. Since the process is largely mechanical straining, the bacterial species are all reduced alike without selective action upon various species present originally, and the danger of infection is therefore reduced in proportion to the efficiency of the filter.

Sanitarians here and abroad have always looked favorably on the elimination of disease carriers by the direct addition of germicides to water supplies, particularly since the effluent of mechanical filters or slow sand filters, improperly operated, may contain many bacteria. Aside from sterilization by boiling, which is impractical on a large scale, various investigators have endeavored to sterilize water by the aid of halogens and their derivatives, by superoxides, by copper compounds, permanganates, caustic lime, acids, etc. Lately the use of ozone and ultra violet rays has been undertaken, with a degree of practical success as yet unascertained.

Of all the chemicals tried at present one alone serves best, that is chlorine, either as gas or in various combinations. Among the various disinfectants mentioned in the past, none is more efficient or economical of application than chlorine in the form most commonly used, viz., bleaching powder.

[2]On the Mills-Reincke Phenomenon, and Hazen's Theorem Concerning the Decrease of Mortality from Diseases other than Typhoid Fever, Following the Purification of Polluted Water Supplies.—Jour. Infec. Diseases, Vol. VII., pp. 489-564.

The first Royal Sewage Commission used calcium hypochlorite for the deodorization of London sewage in 1854.[3] As far back as 1885 the American Public Health Association endorsed it as the best disinfectant available, from the standpoint of cost and efficiency. In 1884 Dibdin again applied it to deodorize London sewage, but the results were unsatisfactory. Traube,[4] and Lode[5] recommended Chlorinated lime, but Bassenge,[6] Rabs,[7] and Engels[8] have not been favorable to its use in the quantities in which it has been applied. Hypochlorite was first used on a water supply on a large scale in Maidstone, Eng., in 1897, to clean the water mains following a typhoid fever epidemic, and again in 1904 and 1905 on the water supply of Lincoln, Eng. Chlorine preparations other than calcium hypochlorite were also tried at Guilford, Eng., at Middlekirk and Ostend in Belgium. Hünermann and Deiter[9] recommend the use of sodium hypochlorite. The action of bleach upon specific bacteria has been studied by Nissen,[10] and a host of observers have directed their attention to its use in the disinfection of sewage. Among them were Proskauer, Elsner, Dunbar, Zirn, Schumacher, Schwartz, Kranepuhl, Kurpjuweit Rideal, Dibdin, Fowler, Houston, Gage, Clark, and Phelps. This list of observers is by no means complete, including only a few of the investigators who have drawn favorable or unfavorable conclusions from the use of chlorine and its compounds for the sterilization of water or sewage.

A great impetus to the use of calcium hypochlorite for water in this country was given by the application to the water supply of Jersey City by C. A. Johnson, in June 1908, and the use of hypochlorite in the Chicago union stock-yards purification plant shortly afterwards. Since then the disinfection of water supplies by the aid of chlorinated lime, either alone or in connection with filtration, has progressed enormously. In every case where chlorinated lime has been intelligently applied the death rate from water borne diseases has decreased. Since some claim that the action of bleaching powder upon some pathogens is selective, a study of the influence on a disinfected water supply upon the mortality other than from typhoid fever

[3]Second Royal Sewage Commission, London, 1861.
[4]Zeitsch. f. Hyg., 1894, p. 149.
[5]Arch. f. Hyg., 1895, p. 236.
[6]Zeitsch. f. Hyg., 1895, p. 227.
[7]Hyg. Rundschau, 1901, p. 1085.
[8]Zentr. bl. f. Bakt., 1902, p. 495.
[9]Deutsch. med. Wochensch., 1901, p. 391.
[10]Zeitsch. f. Hyg., 1890, p. 62.

would be instructive, just as has been done in the case of filtered water supplies. It seems fair to assume that the cases of tuberculosis would not be diminished, since that bacillus is very resistent to chlorine.

The reaction which takes place on placing chlorinated lime in water is fairly well understood. The hypochlorous acid is liberated by the free carbonic acid in the water. The hypochlorous acid in the presence of easily oxidizable matter breaks up into oxygen and hydrochloric acid, and the latter becomes immediately neutralized by the carbonates and bicarbonates. The nascent oxygen which is liberated in the process is responsible for the destruction of bacteria and the oxidation of other organic matter which may be present. Since the available chlorine and the potential oxygen are in direct chemical relation, it suffices for practical purposes to designate the strength of a bleaching powder solution in p.p.m. of available chlorine, although it would probably be more correct to indicate its strength in p.p.m. of potential oxygen.[11]

There is still some question as to the so-called "residual chlorine" left in water after disinfection. It is supposed that the residual chlorine is not chlorine in its free state, but a loose combination of hypochlorous acid and organic matter. The oxidation of mineral salts by bleaching powder is, as a rule, not a matter of great importance in the disinfection of water supplies. In a highly polluted water or a sewage, however, much of the available chlorine may go to oxidize mineral constituents or gases in solution before the bacteria are attacked. The effluent of a biolytic tank at our sewage testing station absorbs as high as 20 p.p.m. of available chlorine without showing a material reduction in the number of bacteria. The chlorine merely oxidizes its equivalent of hydrogen sulphide in the sewage.

The free carbon dioxide in the water is always reduced after disinfection with hypochlorite. The total solids and the hardness are slightly increased. Coloring matter, if present, is not noticeably reduced, neither is turbidity affected. The organic matter is lessened when judged by the oxygen consumed test. Even the best grades of bleaching powder contain impurities, such as calcium chlorate, calcium hydrate, calcium carbonate, calcium sulphate, etc.

In late years the shores of the Great Lakes have become polluted by sewage so that Erie, Toronto, Cleveland, Milwaukee, and other cities have resorted to emergency disinfection. The quantity of

[11]Charles G. Hyde, "The Sterilization of Water Supplies by the use of Hypochlorites," a paper presented to the Santa Barbara meeting, League of California Municipalities, Oct. 26, 1911, p. 10.

"hypo" required by a water will largely depend upon its quality and the degree of contamination. Variations in turbidity will also affect it, particularly when the suspended matter is rich in organic matter. Bartow and Birdsall[12] refer to a case at Fort Sheridan, Ill., where a high turbidity in the water was observed to be accompanied by an increase in diarrheal diseases. The turbidity is greatest during stormy seasons. Observations made by Pearse, Tonney and Bartow,[13] in a survey of Lake Michigan extending from Chicago to Waukegan, showed that in-shore the turbidity may reach 180 p.p.m. One and two miles off-shore, however, the turbidities were low, ranging from zero to 29 for average figures. Beyond a depth of 60 ft. the turbidity was always under 5 p.p.m. This depth occured from 3 to 5 miles off-shore. "Practically all the intakes from Gary, at the small end of Lake Michigan, to Waukegan, are in a zone of turbid water." Bartow and Birdsall[12] found the ranges of turbidity at Lake Forest between 2 and 170 p.p.m., and at Evanston between 5 and 200 p.p.m. C. A. Jennings[14] reports a low average turbidity at Erie, Pa., as well as a low content of bacteria and organic matter. The water supply in Charlotte, N. Y.,[15] taken from Lake Ontario is reported as having an average turbidity of 11.3 p.p.m. Aside from variations in turbidity the chemical composition of the unpolluted waters of the Great Lakes is fairly constant, with the exception of Lake Superior, as shown by the analyses of R. B. Dole and R. G. Roberts.[16]

The quantity of "hypo" applied on a quiet day may not suffice in a storm when the turbidity is high, unless settling basins are provided, as at Erie, Pa. When the turbidity is high it is easily conceivable that "hypo" treatment with the same amount as in low turbidity would only be partly if at all effective. Turbidity usually carries with it an abnormally large quantity of easily oxidizable organic matter, and the coarser suspended particles may harbor millions of bacteria which, thus protected, would escape destruction. In other words, disinfection by itself can not take the place of filtration. It

[12]Composition and Treatment of Lake Michigan Water,—Second Report of the Lake Michigan Water Commission, p. 69.

[13]Report on Sanitary Survey of Lake Michigan, Chicago to Waukegan,—Second Report of the Lake Michigan Water Commission, p. 37.

[14]Typhoid Fever Epidemic at Erie, and Hypochlorite of Lime Treatment Plant at Erie.—Engr. Record, 1911.

[15]The Rochester & Lake Ontario Water Company's Filters,—Engr. Record, 63, p. 626.

[16]The Waters of the Great Lakes. Paper presented before the Am. Pub. Health Assn., at Winnipeg, Man., Aug. 1908.

might if the water supply is always clear, and of uniform quality. In the use of ozone and the ultra violet rays turbidity decreases the efficiency of the method.

Depending upon local conditions, the quantity of bleach applied at the different cities bordering on the Great Lakes varies between 0.2 to 0.4 p.p.m. available chlorine, with the exception of Cleveland, which is using a larger quantity at present. Tests made at our laboratory demonstrated that for slightly polluted water from a 3 mile crib, 0.3 p.p.m. of available chlorine is an ample quantity, and that the time of contact need be very short. Under laboratory conditions, the action is almost instantaneous, but for practical purposes, sanitary engineers recommend a contact period from one half to one hour. 0.3 p.p.m. and often 0.2 p.p.m. is sufficient to eliminate all gas-formers, when the water is fairly clear. The reduction of the total number of bacteria is around 97%. The frequent occurence of spreaders on litmus lactose agar plates is in line with observations made in many places. The "resistant minority" to which spore bearing spreaders, like B. subtilis, belong, does not permit a bacterial reduction of 100% with the quantities in which bleach is ordinarily applied.

Since the use of disinfection at the stock-yards filter plant in Chicago, work, largely of a bacterial nature, has been done in this country on the question of disinfection of contaminated supplies and sewages, in particular by Phelps.[17] Where a comparatively small quantity of sewage is polluting a large water supply, or where sewage is likely to contaminate shell-fish beds, disinfection of sewage may serve a useful purpose. Proof is ample that the typhoid fever bacillus will thus be eliminated, but two serious objections to the method arise: first, the large quantity of organic matter in the disinfected sewage may at any time serve as a culture medium to pathogens under favorable conditions, and second, the pathogenicity of some of the sewage bacteria is either unknown or little understood. Moreover, the germicidal effect of "hypo" upon sewage bacteria has not been sufficiently investigated. In speaking of sewage bacteria, we should remember that although some types have been found in waters and nowhere else, there is really no limit to the variety of species which a contaminated water may contain. Some of the known pathogenic bacteria have as yet not been isolated in a polluted water supply, largely on account of the immense dilution and imperfect working methods. In fact sewage may contain all bacteria known to men,

[17]The Disinfection of Sewage and Sewage Filter Effluents. U. S. Geol. Survey, Water Supply and Irrigation Paper, 229.

pathogens as well as saprophytes. Consequently the action of bleach upon all of these microorganisms should interest the sanitarian. The saprophytes must not be overlooked because their relation to disease is by no means settled.

The bacterial flora of Lake Michigan tap water of Chicago was investigated twelve years ago by Zeit and Fütterer[18] jointly, when the city of St. Louis tried to enjoin Chicago from emptying its sewage into the Illinois river. They found in 7 samples the B.coli communis on three occasions, the B.lactis aerogenes once. Their conclusion was that B.coli communis may be found in water without sewage pollution, and that it may or may not be virulent. Thirteen non-pathogenic species were isolated, among them B.subtilis 4 times, and B.mesentericus 3 times .

The presence of B.coli in a water supply is generally accepted as indicative of fecal pollution, and many studies have been made to compare the viability of this bacillus to its dreaded companion, the typhoid fever baccillus. The evidence shows that both species are of a low resistance, and the elimination of one coincides with the elimination of the other.

In the disinfection of a water with "hypo" the claim is made that the action upon types of intestinal bacteria, such as B.coli and B.typhosi is a selective one. Phelps[17] made emulsions of the two species in tap water, and applied on the average 5 p.p.m. of available chlorine. In a general way the result of his experiments indicate that "B. coli may reasonably be regarded as test organisms in disinfection work, and that the process may be expected to destroy typhoid organisms present, at least as thoroughly." Working on the disinfection of trickling filter effluents at Baltimore, Md., with chlorinated lime, Phelps observed that the removal of B.coli, as indicated by the fermentation test, did not coincide with the removal of acid forming bacteria on the plate. The removal of the B.coli on the plate seemed to be better than indicated by the fermentations. Efforts to discover the discrepancy were but partly successful. Identification of B.coli seemed to indicate that many of the positive tests for fermentation were due to the presence of a fermenting organism other than B.coli.

In this connection some of our observations may be of interest. In applying the solution of chlorinated lime to an emulsion of B.coli in Lake water, we noted repeatedly that a number of the colonies of B.coli on the plates after disinfection did not present the original

[18]Ill. State Board of Health, "Report of the Sanitary Investigations on the Ill. river and its Tributaries, 1900, p. 85.

appearance, but were much smaller than at the start, and failed to produce acid. We are unable to account for the failure of the colonies to turn red on litmus lactose agar. The amount of chlorine is much too small to exert a bleaching effect, and the alkalinity is too slight to neutralize the organic acids formed. The probable explanation is the diminished virility of the bacilli. They may be temporarily "stunned," and it is likely that they become rejuvenated under favorable conditions. The colon bacillus in the water, by itself, is not considered detrimental. Some investigators maintain that the colon bacillus is somewhat of an intestinal scavengar. Where numerous colonies of pathogenic organisms can be cultivated from feces we may find a diminished number of colon bacilli. This condition may be observed in infections with the organisms of dysentery, cholera, typhoid and paratyphoid. Some consider that the B.coli produce a bactericidal substance which inhibits the growth of or destroys pathogenic bacteria which may have passed the gastric juices.[19]

Of the many varieties belonging to the colon group, more must be learned before we can speak with authority on that subject. We do not regard our study of the effect of "hypo" upon colon bacilli as concluded, but wish to record our observations. More detailed work can be taken up at a future date. It has been noted by J. W. Ellms[20] in the disinfection of Ohio river water that certain saprophytes multiplied profusely after disinfection with chlorinated lime, and one of Ellms' conclusions is that bleaching powder is apparently not a true sterilizing agent, but rather one which inhibits bacterial growth upon culture media. It would seem that this would apply also to bacteria other than of the spore bearing type.

On using a lake water emulsion containing a pure culture of B.coli, the reduction with 0.3 p.p.m. available chlorine amounted, as a rule, to 99.6% after the first 5 minutes. The initial counts varied in the different experiments from 3,000 to 500,000 in 1 c.c. A blank was always made on the lake water without a bacterial emulsion.

We would like to emphasize that percentage reduction figures are not of such great importance as the initial number of the bacteria. With one and the same water supply such figures may serve as an index of the efficiency of a "hypo" plant. Where different sources of water supply are treated the difference in the bacterial flora might

[19] E. R. Stitt, "Practical Bacteriology, Blood Work and Animal Parisitology", p. 91.

[20] "Effect of Bleaching Powder upon Bacterial Life in Water." Eng. Record, 63, 471.

account for differences in percentage reduction figures. Furthermore, in an artificial bacterial emulsion the percentage reduction will appear greater the larger the initial count has been. It is not likely, however, that the difference would be material, since our experiments and the experiments of others have shown that with a sufficient quantity of chlorine the reduction of B.coli has been fairly uniform whether the initial count was high or low. For practical purposes it seems that it is not so important to try to obtain a reduction of 99%, instead of 97%, or thereabouts, as it is to obtain information on the pathogenicity of the residual number. There is also danger of introducing small quantities of organic matter or other oxidizable matter with the emulsion. Possibly this would coincide with the small amount of organic matter present in a contaminated sample.

Similar experiments with a number of pure cultures of bacteria likely to be present in contaminated water and sewages are of interest.

A number of spore bearing bacteria were treated in a like manner, and varying quantities of "hypo" were applied in order to test their viability under such conditions. N. S. Hill, Jr.,[21] states that bleaching powder applied as a disinfectant to water does not destroy spore bearing bacteria, such as B.aerogenes capsulatus, B.butyricus and B.cadaveris sporogenes. The cultures taken for our experiments were B.subtilis, B.mesentericus rosei, B.mesentericus fuscus, and B.anthracis. Only the last one is considered pathogenic to man. The difficulty of eliminating the spores of subtilis has always been a source of annoyance. As high as 400 p.p.m. of available chlorine did not entirely eliminate the colonies. The following table shows the percentage reduction obtained with various amounts of "hypo."

TABLE I.

Percentage Reduction of B. Subtilis on Disinfection
With Calcium Hypochlorite.
15 min. Contact Initial Count 450 in 1 c.c.

p. p. m. Avail. Chlorine	Percentage reduction
25	3
50	43
75	50
100	75
200	89
300	93
400	95

[21]Bleaching Powder as an Agent in the Purification of Water. Eng. Record, 63, 491.

The large amounts of chlorine necessary to obtain a material reduction in the number of the so common B.subtilus illustrates better than anything else the impossibility of obtaining sterile plates with the amounts ordinarily applied. The spores of anthrax which belong to the same group seem to be very much less resistant to chlorine. 50 p.p.m. of available chlorine nearly eliminated it, while 100 p.p.m. resulted in a sterile plate. The period of contact was 15 minutes, just as in the case of all other species, this being considered ample from a working standpoint. The experiments with B.anthracis are of more theoretical than practical interest. Infection of man from a water supply containing anthrax is very remote. The bacillus has been isolated, however, in a contaminated water on numerous occasions. Zeit and Fütterer[18] found anthrax twice in the Illinois river at Havana. Statements of the quantities of chlorine necessary to destroy the bacillus differ greatly in various text books and journals.

TABLE II.
Percentage Reduction of Anthrax Spores
On Disinfection with Calcium Hypochlorite.
15 Min. Contact—Initial Count 12,000 in 1 c.c.

p. p. m. Avail. Chlorine	Percentage reduction
10	95.8
15	97.7
20	99.3
30	99.5
50	99.9
100	100

Much smaller quantities of "hypo" were necessary for the destruction of other spore bearing bacteria.

TABLE III.
Percentage Reduction on Disinfection
Of Spore Bearing Bacteria with Calcium Hypochlorite.
15 Min. Contact.

p. p. m. Avail. Chlorine	200 in 1 c.c. B. Mesenter rosei	1900 in 1 c.c. B. Mesenter fuscus
0.1	....	....
0.3	....	....
0.5	....	....
0.7	....	....
1.0	....	....
2.0	....	....
3.0	....	....
4.0	....	....
5.0	80.0	26.4
10.0	75.0	31.6
15.0	80.0	52.7
20.0	100.	60.6
30.0	....	60.6

There seems to be a great difference in the resistance of various spore bearing species towards chlorinated lime. Checks on the results have not always given the same percentage reduction, but the figures coincide closely enough to the results tabulated.

Not only the aerobic spores but also the anaerobic spores are very resistant to chlorine. On disinfecting a sample of sewage with as much as 10 p.p.m. of available chlorine, spores developed on incubation in the Novy jar. The well known anaerobic spore bearer,—the tetanus bacillus—has been isolated by Zeit and Fütterer[28] in the Illinois river at Morris and Henry, Ill., and in the Spoon river at Havana, Ill.

The important group of intestinal bacteria is much less resistant than the spore bearing group, as might be expected. The B.mirabilis, belonging to the proteus group has proven an exception, suggesting the presence of spores. Even 5 p.p.m. of available chlorine has not entirely eliminated the bacillus. The other figures indicate, however, that even under severe conditions 0.2 p.p.m. of available chlorine is sufficient for practical purposes. The effect of chlorine upon the B.typhosus has been exhaustively studied by various investigators, and it has therefore been omitted from our work.

TABLE IV.

Percentage Reduction on Disinfection of the Group Of Intestinal Bacteria with Calcium Hypochlorite. 15 Min. Contact.

	160,000 in 1 c.c.	9,500 in 1 c.c.	3,000 in 1 c.c.	8,000 in 1 c.c.	180,000 in 1 c.c.	180,000 in 1 c.c.	500 in 1 c.c.
p.p.m. Avail. Chlorine	B. cloacea	B. faec. alcalig.	B. Para-typh.	Prot. mirabilis	B. enter-itidis	B. lactis aerog.	B.choler-suis.
0.1	......	99.98	......	27.3	......	......	......
0.2	99.69	99.99	99.97	45.5	99.83	99.17	95.8
0.3	99.75	100	100	63.7	99.98	99.98	100
0.5	100	......	......	72.7	100	100	......
0.7	......	......	......	63.7	......	......	......
1.0	......	......	......	63.7	......	......	......
3.0	......	......	......	90.9	......	......	......
5.0	......	......	......	90.9	......	......	......

Two chromogenic species, the B.pyocyaneus (green pus bacillus), and sarc.lutea were tested for their resistance. 0.3 p.p.m. of available chlorine proved sufficient to eliminate both species. B.acidi lactici was likewise completely destroyed by 0.3 p. p. m. of available chlorine.

Time did not permit us to follow the investigation further. In a general way the results coincide with the work of other observers, and with the assumption that all but the hardier species, such as the spore bearers, are effectively destroyed with quantities of hypo as ordinarily applied.

A question which may possibly be asked in connection with the disinfection of lake water is in regard to the rate of bacterial destruction under winter and summer conditions. The lake water temperature at Chicago may vary 36 degrees Fahr. from summer to winter. Disinfection with chlorinated lime is a chemical process, and as such is facilitated by higher temperature. Other conditions being equal, we have to consider that during winter conditions the bacterial content in the lake is lower and the dissolved oxygen higher. This would seem to indicate that less chlorine would be needed in winter. Phelps[17] in his work on the disinfection of sewage and filter effluents, considered the amount of oxygen present as an important index to the character of the sewage or the effluent in reference to its effect on chlorine. He found the disinfection of the oxygenated filter effluent much less influenced by temperature changes than de-aerated sewage. In the light of his observations it seems fair to assume that with the

highly stable lake water, even if contaminated, temperature changes would make but little difference. We have made some experiments on this question and found the assumption to be correct, when the customary quantities of "hypo" were applied. Sterile flasks containing 100 c.c. of Lake Michigan water were artificially contaminated, each with the same number of B.coli in one case, and B.acidi lactici in the other. They were brought to a temperature of 32, 50 and 69 Deg. Fahr., and then treated with 0.2 and 0.3 p.p.m. of available chlorine. Samples were plated out on litmus lactose agar after 5 minutes, 15 minutes, 30 minutes and one hour. The various counts showed slight differences, but no systematic increase or decrease in the number of bacteria could be recorded in any case. The lake temperature, as a rule, does not go above 68 degrees F. in summer and therefore there seemed no need for carrying on the experiments at a higher temperature. Still there is a possibility that a higher temperature would tend to bring out differences in the rate of bacterial destruction. J. W. Ellms[20] demonstrated, on disinfecting Ohio river water, with a hypo solution containing 0.2 p.p.m. of available chlorine, that a lower temperature retarded the rate of disinfection. His observations refer to temperatures ranging from 38 to 89 deg. F.

The most important question confronting the sanitarian is a possibility of a taste in the disinfected water. Nothing has discredited the "hypo" treatment more than excessive doses, accidental or otherwise. In many cases the quantity of "hypo" may have been reduced to an unsafe minimum either on account of such mishaps in the application, or on account of popular prejudice. The idea of drinking disinfected water seems to be repugnant to the broad masses. Of late, however, thanks to the educational campaign carried on by people interested in public health, and by progressive journals, the prejudice against the use of "hypo" is decreasing. When properly applied, the taste of sterilized water is mainly the result of auto-suggestion. This can readily be proven in a practical test, as carried on in our laboratory. At one time, we took a squad of 8 men, none of whom had ever tasted "hypo" in water before, prepared a series of bottles containing lake water with various quantities of "hypo" and distributed a number of blank bottles containing lake water among the "hypo" samples. When a water supply is treated with "hypo" the consumer expects to taste "something" in the water. That is the frame of mind also in a laboratory test. As might be expected, a number of the squad tasted "something" in lake water containing no "hypo" at all, and one man even discovered an odor in one of the blanks. Recently we repeated the test in order to check the results first obtained, in regard

to the limit of noticeable taste and odor. The results coincided fairly well with the earlier ones.

We have been impressed with the necessity of certain precautions, in order to make such a physiological test a success. A chemical laboratory is a poor place for such a test. The laboratory worker being constantly in an atmosphere more or less saturated with odors foreign to pure air, grows accustomed to such conditions, and is likely to miss an odor or taste, no matter how slight, which would be suggested to a man unaccustomed to laboratory conditions. Care must also be taken to rinse the mouth thoroughly with pure water after tasting each sample. If one were to start with the lowest concentration and consecutively taste the samples, gradually increasing the strength, he would probably pass a sample which he might have detected had he rinsed his mouth with pure water each time. It is much better to start, say with 0.1 p.p.m. and then pass right on to the 0.4 p.p.m. sample. If there is a slight taste he is likely to detect it much better than if he would have sampled the 0.2 and 0.3 water. A squad representative of the average grade of people must also be selected. The chlorine is tasted long before its odor is noticed. Since the claim is often set forth that in the application of hypochlorite, other substances in addition to the chlorine may be responsible for the acrid taste, a series of samples was arranged containing various quantities of free chlorine gas in solution, the gas being prepared by the action of sulphuric acid upon bleaching powder.

The following tables (V and VI) show the difference between the taste and odor observed by our squad, when using chlorinated lime and aslo free chlorine.

TAVLE V.

Observations as to Taste and Odor of Lake Michigan Water Containing Various Amounts of Free Chlorine.
February 27, 1912.

Serial No. of Sample	p. p. m. Available Chlorine	Observer. 1	2	3	4	5	6	
I.	0.0	—	—	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
II.	0.1	—	—	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
III.	0.2	—	—	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
IV.	0.3	—	—	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
V.	0.4	?	—	—	—	—	?	Taste
		—	—	—	—	—	—	Odor
VI.	3.0	+	—	+	?	—	+	Taste
		—	—	—	—	—	—	Odor
VII.	0.6	+	—	+	?	—	+	Taste
		—	—	—	—	—	—	Odor
VIII.	0.7	+	+	+	+	—	+	Taste
		—	—	—	—	—	—	Odor
IX.	0.8	+	+	+	+	—	+	Taste
		—	—	—	—	+	—	Odor
X.	0.9	+	+	+	+	?	+	Taste
		+	—	—	—	+	+	Odor
XI.	1.0	+	+	+	+	+	+	Taste
		+	+	+	+	+	+	Odor
XII.	2.0	+	+	+	+	+	+	Taste
		+	+	+	+	+	+	Odor
XIII.	3.0	+	+	+	+	+	+	Taste
		+	+	+	+	+	+	Odor

TABLE VI.

Observations as to Taste and Odor of Lake Michigan Water Containing Various Amounts of Chlorinated Lime.
February 27, 1912.

Serial No. of Sample	p. p. m. Available Chlorine	Observer. 1	2	3	4	5	6	
I.	0.0	—	—	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
II.	0.1	—	—	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
III.	0.2	—	—	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
IV.	0.3	—	—	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
V.	0.4	+	?	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
VI.	0.5	+	+	—	+	—	—	Taste
		—	—	—	—	—	—	Odor
VII.	0.6	+	+	—	—	—	—	Taste
		—	—	—	—	—	—	Odor
VIII.	0.7	+	+	?	—	—	—	Taste
		—	—	—	—	—	—	Odor
IX.	0.8	+	+	+	—	—	—	Taste
		—	—	—	—	—	—	Odor
X.	0.9	+	+	+	—	?	—	Taste
		—	—	—	—	—	—	Odor
XI.	1.0	+	+	+	+	+	+	Taste
		—	+	—	+	—	—	Odor
XII.	2.0	+	+	+	+	+	+	Taste
		?	+	+	+	—	+	Odor
XIII.	3.0	+	+	+	+	+	+	Taste
		+	+	+	+	+	+	Odor

If we make allowance for individual mistakes, we are justified in stating that there is no material difference between the taste of free chlorine and "hypo." The average is somewhere around 0.6 p.p.m. of available chlorine, but 0.5 p.p.m. can often be detected. It seemed however, that the odor of the gaseous chlorine sample was detected

sooner than it was in the "hypo" sample. To identify the odor, on the average, 1.8 p.p.m. of available chlorine was required in the bleaching powder sample, and 0.9 p.p.m. in the free chlorine sample. The free chlorine is perhaps more volatile in a water thus treated, and the water would rid itself quicker of the odor of the chlorine than in the "hypo" treated sample. The tasting squad consisted of six people. They were set to work a few minutes after the preparation of the various dilutions. The time element is to be considered. The water treated with "hypo" or chlorine will lose its taste and odor in due time, depending upon the concentration. Our results are in harmony with some experiments carried on at the laboratory of the Illinois State Water Survey. Van Brunt[22] claims that about 0.6 p.p.m. of available chlorine could be tasted.

In closing we wish to state our opinion that the process of hypo disinfection has great merit from a practical working standpoint as well as from the standpoint of the sanitarian. It is cheap, but it can not supplant filtration except under favorable circumstances. It seems effective as a germicide, but the relation of "hypo" sterilization to mortality statistics other than typhoid fever still remains to be demonstrated.

DISCUSSION.

Chairman: Have you studied the question of the purification or sterilizing of swimming pools with "hypo."

Lederer: We have not. We do not have occasion to do that but there are numerous instances where the purification of swimming pools has been studied. There was an excellent paper presented on the subject before the Association at its last meeting by Dr. Atkins of the University of Chicago. He has made a thorough study of the matter. Dr. Atkins studied the disinfection of the Chicago University swimming pool. Prof. Lewis has done similar work on the swimming pool of the Northwestern University.

Park: Do I understand that the hypochlorite is used in a dry powder?

Trow: I mix 3 lbs. with four thousand gallons of water and in the course of 24 hours discharge this solution into the suctions of the pump. The flow is regulated by a valve on the pump. I do not quite understand just what is meant by .2 parts of available chlorine per million. What does that mean in pounds of "hypo" per million?

[22]Univ. of Ill. State Water Survey Bulletin 8, 53.

Hansen: 25 lbs. of clorinated lime added to one million gallons of water gives approximately one part per million of available chlorine, assuming that the chlorinated lime has 33% available chlorine. .2 parts per million of available chlorine is equivalent to 5 lbs. of bleaching powder in one million gallons of water.

Trow: We got good results with 3lbs. per day but if we use excess of this, 5 or 6 lbs., we get odors and tastes noticeable to a consumer.

Lederer: What water is used?

Trow: Lake Michigan water.

Hansen: The quantities Mr. Trow mentions are rather small to give a taste and odor to the water. I would like to ask if he will describe the taste and odor that does occur?

Trow: Most always notice able when a fresh can is used and the taste corresponds to the smell of leaves in the fall after a rain. Personally I could not detect the odor but could taste it only when a fresh can had been opened. We have bought it in large quantities in sealed barrels but when we get down to a quarter of the barrel there is no strength left.

INCRUSTATION IN WATER MAINS AT MT. VERNON, ILLINOIS.

BY F. M. SINSABAUGH.*

In presenting this paper, it would be well to give you first a history of the water plant in Mt. Vernon, calling only your attention to the fact that, in Southern Illinois, the only method of obtaining water is from existing creeks or rivers, or damming up ravines, impounding such water as is furnished by adjoining watersheds. There are no springs, or water bearing strata of gravel, from which to obtain a supply. It is true that some towns in Southern Illinois have bored wells to a great depth, but they have not obtained water that is satisfactory for domestic and industrial use.

About twenty-three years ago a freight car manufacturing company moved their plant from Litchfield, Ills., to Mt. Vernon, installing their equipment in some buildings belonging to the L. & N. Ry., situated in the heart of Mt. Vernon. These buildings were abandoned by the L. & N. when they moved their division shops to McLeansboro.

The L. & N. Ry. had secured their water by damming a small ravine west of town, the dam serving as a roadbed for their tracks. At this point they installed a small pumping station, pumping their water along the right of way to the car shops, where they erected a small water tank. They also placed a tank near their passenger station, making two places for their engines to obtain water.

The Car Manufacturing Co. soon found that the amount of water furnished by the small pond was inadequate; and as there was a larger ravine north of this pond, they purchased this ground and built a dam, giving them a reservoir covering fifteen acres, obtaining a supply from a much larger watershed. They started their pipe line from the reservoir, running an eight inch line 2100 feet, to a point near the L. & N. station. Here it was reduced to six inch, and continued on Broadway to Ninth St., which is the southeast corner of the public square, a distance of 3950 ft.

A number of the business men called on the President of the

*General Manager, Citizens Gas, Electric & Heating Co.

Car Co., and endeavored to have him place some fire plugs along the line, to give them some fire protection. As he did not care to enter into the water supply business further than for his own use, he proposed turning the proposition over to a company that they might form, then he would purchase water from them. A company was formed among the business men, and the mains were completed to the car works, and a few fire plugs installed. Business was solicited along the mains then in the ground.

The demand for water increased very rapidly, and they used no discretion in their extension of the system, looking more to the present needs than to what they might expect in the future. In this manner they installed a great number of small mains, in most cases merely of wrought iron, which you know has a very short life.

It was not long until they found that there was not enough water in the pond to supply the needs of the town, so they installed a small auxiliary station on a little creek outside the city limits. This creek is considerably lower than the town, and they placed a low duty pump at this point, and ran a six inch line over to the reservoir, this has since been replaced by a 12 inch line. Of course their main pumping was from the reservoir.

About this time the municipal ownership bug hit the city council. and they thought it was the thing for the city to own the water works. They made arrangements to buy it, together with a small electric light plant that was situated here. They moved the electric light plant to the pumping station, installing the machinery in the same building with the pumping outfit. In order to acquire this property and make some extensions, they issued water fund certificates to the extent of some fifty thousand dollars.

But municipal ownership was not as rosy as it had been pictured, and when the first interest was due on these water certificates, they had no money to meet it, so the entire property fell into the hands of a party of bond-brokers, who had underwritten the securities. The bond brokers assumed control and rebuilt the electric light plant, where the present plant now stands, adding thereto a gas works and hot water heating equipment.

About this time the car manufacturing plant was doing a great amount of work and the town grew rapidly, gaining 50% in ten years. Necessarily the consumption of water grew greater each year, and again it was found that the supply was inadequate. There were times when the small creek and the ponds did not furnish an adequate supply, and in extremely dry weather they had to ship water in in tank cars. It is rather amusing to know how they used to handle

that. Water being so scarce they had thretaened to turn off all the residences and only furnish the industrial plants, keeping a reserve for fire protection; but they made a proposition to all private consumers, that each one who would buy a tank car of water and place it in the reservoir, could stay on.

As the question of water supply had become so serious a proposition, they employed engineers to ascertain where they could best locate a reservoir to increase the supply. They finally decided on a position some four and a half miles north of town, damming up a large ravine. In order to do this they had to buy up some three hundred acres of land, where they were enabled to impound something over three hundred million gallons, which, up to the present time, has been sufficient to furnish all needs. Although during the summer and fall of 1911 the situation was getting a little shaky. We have since raised the spillway at the new reservoir and strengthened the dam, giving us some thirty or forty million gallons additional supply.

During the twenty or more years that this plant has been in operation there have been no steps taken to purify or filter the water, and naturally an incrustation has formed in the pipes. The party of bond brokers who purchased this property met with reverses a few years ago and were unable to furnish the plant with the necessary funds to keep it in good working order. The property passed into the hands of the present owners in December, 1910, when I assumed charge.

Soon after this a small fire occured and we found that, with 100 pounds pressure at the pumping station, and two three quarter inch fire nozzles, the fire department was unable to throw a stream into the second story of the building. I was very much surprised at this, and soon learned what was the trouble. The Superintendent of the pipe lines, who had been with the company for some nine or ten years, informed me of the conditions of the mains.

Soon after this the National Water Main Cleaning Co. were cleaning the mains in Centralia and, with the Superintendent, I went to investigate their work and found wonderful results. I immediately made a contract with them to clean a main artery through the town to the car works, which would naturally be the oldest and dirtiest main in town. I might say that the Car Co. had just completed a large plant for manufacturing steel cars, around which we had put twelve fire hydrants. They, knowing the condition of the mains, were very much exercised and were anxious to see the condition bettered, so that they would be assured ample fire protection.

Before cleaning the mains we made a test at the southeast corner of the square, which is about 4000 feet from our pumping station. To the plug at this point we attached a two and a half

Fig. 1. Fire Stream, Mt. Vernon, Before Cleaning Mains.

Fig. 2. Fire Stream, Mt. Vernon, After Cleaning Mains.

inch fire hose, with one and a quarter inch nozzle, and placed a guage on the other outlet to the fire plug. With one hundred pounds pressure at the pumping station we were enabled to throw a stream such as you see in Fig 1. The pressure registered at the hydrant was 15 pounds. You will note that the man holding the nozzle is doing it with one hand, and with as much ease as though he was pouring a cup of tea. The distance this stream was thrown is 68 ft.

After we had cleaned this four thousand feet of main we again made the test, with the result shown in Fig. 2. You will note that it took two men to hold the nozzle, and they kept hurying the photographer, as they said it was going to get away from them. The gauge at the fire plug registered 52 pounds, with the same pressure at the pumping station, i. e. 100 pounds, so you see we had a gain of 37 lbs. This picture was taken at the same angle as the former one, and you will note that you cannot see the end of the stream.

The water was thrown 204 ft., compared with 68 ft. before the cleaning.

We were so well satisfied with the work done by this company that we made a contract with them to clean all our mains. When same was completed we found that we were able to reduce our domestic pressure from twenty to twenty-five pounds, and deliver water to patrons at a greater pressure than before. While the work cost us $6,500.00 for cleaning 45992 ft., we feel that the results have justified the expenditure.

It may be interesting to you to learn how the Water Main Cleaning Co. go about this work. The first thing they do is to close a valve feeding the main to be cleaned. Then they cut out a three foot section of the main just beyond the valve, into which they insert an instrument called the carrier, which is a rod about three feet long, to which is attached conical leathers with the apex away from the valve. These cones are made of ample area so as to completely cover any outlets to this main.

To this carrier is attached a small wire cable. Then a temporary makeup is placed in the opening and the water is turned on. The pressure floats this carrier to the end of the section to be cleaned, carrying the small cable with it.

At this end they break out a section and make a temporary connection with a forty five, which conveys the water to the surface, where it is carried off by the side gutters on the street. When this carrier reaches the other end of a section, it is detached and a

larger cable is fastened to the small one. Then, with a windlass, the larger cable is pulled back to the point of beginning.

To the large cable is attached the cleaning tool, which consists of several sections with swivel joints, and a series of scratching and scraping arms. The section first taken out is then leaded in permanently, and the water is turned on.

The cleaning tool is then drawn through by a wench, which requires four to six men to operate. As the cleaner is pulled along, the water behind it washes all the deposits out. It is amazing the amount that is taken out at each draw.

The length of sections cleaned varies from four to twelve hundred feet, according to the manner in which the mains are laid.

Not only does the cleaner remove the incrustation in the mains, but it will also find any obstruction, such as an accumulation of lead from a poorly poured joint. In our case they found a number of pump valves lodged in different places, and a number of pieces of wood, one of which was a 2x4 about six feet long, and another was a fence rail. These had either been maliciously inserted, or had

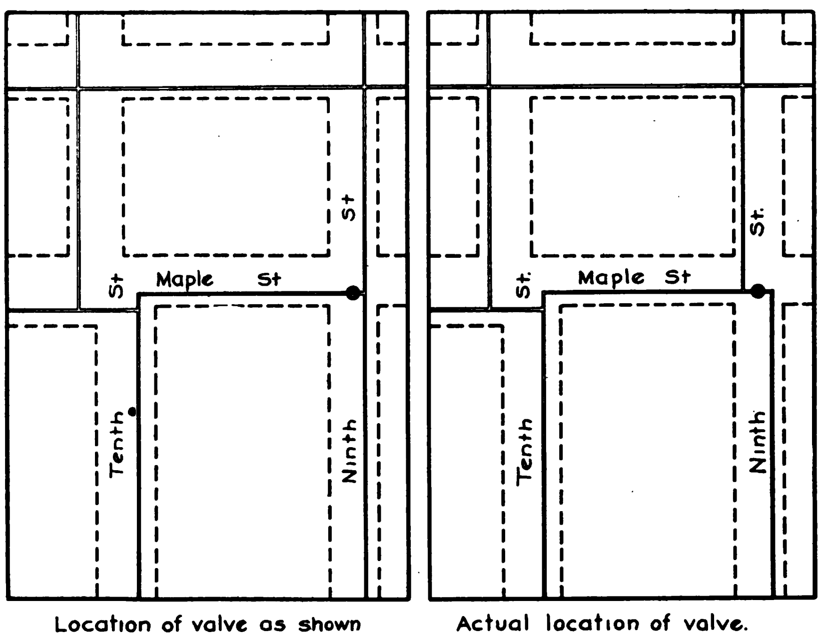

Fig. 3. Correction of the Map Showing Location of Valves, Mt. Vernon.

been used by the wokmen, when laying the pipes, for carrying same, and had been left in the pipe carelessly.

Another benefit we found was that we were able to correctly locate our valves, and soon found out those that were not in perfect working order.

Fig. 3 will serve to demonstrate how easy it is to have the wrong location of your valves on the map. On the left of this slide you will find how the location was shown on our map; but upon cleaning these mains, we found it was located as shown on the right. This was not discovered until we had cleaned a considerable amount of mains in this territory. Had we known the exact location, it would not have been necessary for us to cut off as much of that part of the town as we did.

Pieces of our mains and service pipe show in what condition they were. A section of 6 inch main has been dipped in parafine, to keep the incrustation from crumbling. It shows how much incrustation was in the main, and how much the capacity was reduced.

A section was cut out of a service pipe, which includes part of the lead gooseneck, the brass union screwed to the iron pipe.

We find that there is no formation in the lead service pipe, but always find it in the iron service pipes; and where iron pipe was screwed into a brass fitting, there was always more incrustation than anywhere else.

COMPOSITION OF THE INCRUSTATION IN THE MT. VERNON WATER SYSTEM.

BY H. P. CORSON.*

In April 1911, the attention of the State Water Survey was called to the conditions existing in the water system of Mt. Vernon, Illinois. Incrustation had been gradually forming in the mains until the pressure in many parts of the system had become greatly reduced and in some cases complete stoppage had resulted. The paper by Mr. Sinsabaugh has taken up the mechanical side of the problem and its solution by cleaning the mains. The chemical side of the problem, however, presents phases which are very interesting, and perhaps unusual, at least among the water problems of Illinois in that manganese is present in quantity.

In April, 1911, we received three short pieces of ¾ inch pipe taken from different parts of the system. They had been in service for a considerable length of time, and were partially filled with a dark brown, flaky incrustation. An analysis of this incrustation showed that in addition to the substances invariably found in such deposits, namely, silica, iron, aluminium, calcium and magnesium, these samples contained manganese in considerable quantity. They contained from 8 to 12 per cent of manganous oxide.

Mr. Sinsabaugh sent us three additional samples a short time ago to be used for a confirmatory examination.

Sample No. 1 was collected from the mains. It was brittle and flaky in structure, and of a light brown color.

Sample No. 2 was from a piece of ¾ inch service pipe, which had been in service eighteen years, and was almost completely closed. The deposit was of a very dark brown color.

Sample No. 3 was also from a ¾ inch pipe which had been in service for eighteen years. The pipe was not only almost completely closed by incrustation, but was so corroded as to be almost completely eaten through in places.

These samples were ground, dried at 110°, and analyzed with the following results:

*Chemist Illinois State Water Survey.

ANALYSES OF INCRUSTATION
from
WATER SYSTEM AT MOUNT VERNON, ILLINOIS.

	No. 1 from mains Percentage	No. 2 from ¾" service Percentage	No. 3 from ¾" service Percentage	
Silica	3.62	14.43	10.64	SiO_2
Ferric oxide	79.10	45.44	63.42	Fe_2O_3
Alumina	2.19	5.41	3.44	Al_2O_3
Manganous oxide .	Trace	11.31	5.50	MnO
Calcium oxide	Undetermined	3.97	1.77	CaO
Magnesium oxide ..	Undetermined	1.95	.71	MgO
Loss on ignition..	15.31	17.22	14.65	Organic matter, etc
Total........	100.22	99.73	100.13	

The significant features in these analyses are the amounts of maganese which the samples contain. Strange to say No. 1 contains only traces of manganese, while No. 2 and No. 3 contain 11.31% and 5.50% of manganese oxide respectively.

The source of supply at Mt. Vernon is a small stream, upon which an impounding reservoir has been constructed.

Two analyses of the mineral content of the water have been made at different times with the following results:

MINERAL ANALYSES OF CITY SUPPLY OF MOUNT VERNON, ILLINOIS.

	21908 Apr. 29, 1911		22993 Mar. 2,1912		
	Parts per Mil.	Grains per Gal.	Parts per Mil.	Grains per Gal.	
Potassium Nitrate	3.4	.20	4.6	.27	KNO_3
Potassium Chloride	7.4	.43	5.7	.33	KCl
Sodium Chloride..........	10.7	.62	8.7	.51	NaCl
Sodium Sulphate	86.9	5.07	72.8	4.24	Na_2SO_4
Magnesium Sulphate	131.5	7.67	136.4	7.96	$MgSO_4$
Calcium Sulphate	78.1	4.56	73.8	4.30	$CaSO_4$
Calcium Carbonate	38.4	2.24	45.7	2.65	$CaCO_3$
Ferrous Carbonate	1.7	.10	1.0	.06	$FeCO_3$

Manganous Carbonate	1.3	.08	1.2	.07	$MnCO_3$
Alumina	2.2	.13	2.0	.12	Al_2O_3
Silica	8.2	.48	13.2	.77	SiO_2
Bases	1.1	.06	1.5	.09	Bases
Total.................	370.9	21.64	366.6	21.37	

In connection with the incrustation, the iron and the manganese are the important factors in the mineral content of this water. The amount of iron is from .6 to .8 parts per million, while the manganese content is .64 and .58 parts per million respectively. The amount of carbonate is very low compared with other waters from similar sources.

In many cities in the state, a great deal of trouble has been caused by waters high in iron causing incrustation by precipitation of the iron. This is the first case, however, which we have found in this state, and one of the few places in the country where manganese has been found in incrustations.

Since this manganese bearing water has come to our attention, a number of other waters of the state, similar in character, have been examined for the presence of manganese. Only traces have been found. We would appreciate it, if any of the water works men of the state who know of incrustations, would acquaint us with conditions and furnish samples for examination.

DISCUSSION.

Monfort: I am very much interested in this matter. A few years ago at a point in Texas a similar occurance was developed. In this case the service pipes were blocked completely and the matter that collected was dark brown, in appearance not unlike manganese dioxide. I would like to ask the speaker whether he tried the action of hydrochloric acid on the incrustation.

Corson: I tried the action of hydrochloric acid, and obtained slight chlorine liberation.

Monfort: The material seems thus to have been one of the higher oxides of maganese. Another question. Was there any evidence of organisms in the residue itself?

Corson: A sample of the deposit was received and examined for the presence of crenothrix. None was found, however, but the sample had been shaken up and the deposit so broken up, that the examination was not perfectly satisfactory.

Monfort: The question of Mn determination in all water analyses, especially in the southern part of the state, I think should be

studied in connection with the investigation of organisms which may deposit the material in the form of oxide. I think this is good material for the State Survey to take up in connection with these analyses. In a great many waters of this section there is that same amount, .2 parts per million, in the water and while it is very insignificant, if the conditions are favorable, by reason of the presence of diatoms, or algae, or of decomposing organic matter, serious trouble may arise in distribution as at Mt. Vernon and at several other points the country over. At Mt. Vernon the cleaning of mains has given temporary relief; adequate treatment of their water supply must be resorted to if the recurrence of trouble is to be avoided.

Ely: How thick was the incrustration in the mains?

Sinsabaugh: We found that the incrustation in our mains was not regular in its formation. Some places it would be only about three eighths of an inch thick, but would be studded with buttons about as large as a man's hand, which would vary in thickness from one inch to one half the diameter of the pipe. In some places we would be unable to see through the mains. This uneven surface of course caused a great frictional loss. I had expected to have a sample of the main here to show you, but the Water Main Cleaning Company people got their wires crossed and it failed to arrive."

Parkin: I do not think that we have been troubled with it in the mains in the northern part of Illinois. We have not been in my own city. We have made some extensions this year and cut 16 in. pipe that was as bright as when put in, no crenothrix or deposit of any kind. We have been using river water filtered until lately. We are watching closely because of changing of water to artesian supply.

ILLINOIS LEGISLATION ON PUBLIC UTILITIES COMMISSION.

BY HONORABLE WILLIAM P. HOLADAY.*

The only word of apology that I have for being here this afternoon is that Senator Dailey was taken ill last night and is not able to be here today. I did not have time to prepare an address of such a nature as would be a credit to this Association, not having the time, the few remarks I will make will be entirely extemporaneous, simply outlining to you briefly what has been done and what we propose to do with reference to Legislation on the Public Utilities Question.

For the first time in the history of Illinois the question of Public Utility Legislation was seriously considered at the last session of the Legislature convening in January, 1911. At that session there were some three or four bills introduced on this subject. There were hearings on them both in the Senate and in the House. It was a question that was practically a new one to the members of the Senate and the House. It was new to the people of the State of Illinois. The members recognized the importance of a proposition that would take under its control and would affect directly or indirectly all of the large business interests of the State, the public utilities of every kind, transportation, lighting, heat, telephone, water and various other kinds. In the limited time we had to consider this question, it was our opinion that it could not have proper consideration. So a commission was appointed consisting of ten members, five from the Senate and five from the House, to investigate this question, visit the various states that have public utility laws, collect all information that we could and report back at a future session of the Legislature, reporting the information that we were able to gather and also our conclusions and if we thought advisable, to prepare a law and submit it for the consideration of the next Legislature. In pursuance of the resolution appointing this committee Senator Dailey was elected by the commission, Chairman. I was elected Secretary.

*Member 47th General Assembly, Illinois.

We have had several meetings during the past summer, visited the states of Wisconsin, New York, and Massachusetts, meeting their commissions, and also the commission from the State of Connecitcut. We have been astonished to find the scope and importance of this law as applied in the several states.

There are several propositions in connection with Public Utility Law in Illinois that will be peculiar to the State of Illinois in order to meet conditions that you do not find in other states. In Wisconsin one commission has control of the entire state. Here in Illinois we have the same proposition that they have in the State of New York, the big city, Chicago, with its own questions, not only public utility questions, but every question that comes before the Legislature. The city of Chicago by reason of its size and conditions will present a situation that is different from the situation down state. The same thing is true of New York. In New York they have two commissions, the up state, commission having jurisdiction of the entire state outside of the city of New York, and the City commission having jurisdiction in the City of New York. Their jurisdiction is practically fixed by the dividing line between the city proper and the state. The commissions of Massachusetts are working along the same lines.

The Illinois Legislative Public Utilities Commission has not made any report and will not until the next sesson of the Legislature, you will therefore understand that any opinion that I express will be my individual opinion. As the result of the investigations we have made I am of the opinion that two separate commissions will be necessary in the State of Illinois, one in Chicago and one down state, because each one of them will have more work to do than the public utilities commission of the State of Wisconsin. We have held meetings throughout the southern and central parts of the State. We intend to hold meetings in the principal cities of the northern part some time this summer, probably in a few weeks and then open sessions in Chicago, and later in the city of Springfield, and we hope to have ready for the next session of the Legislature a report presenting the information that we have gathered.

I think that the minds of the members of this Commission, when they were appointed, were entirely open on this question. Recognizing the importance of the proposition they have entered into it in good faith, with the intention of treating the public fairly and at the same time treating the owners of the public utility companies fairly and to formulate a law that will be of mutual benefit. As to how well we will succeed is something that time alone can tell. I think I am safe in saying that throughout the State generally the proposition of a

public utilities law has been favorably received. Some cities that we have visited have been opposed to it but I believe the majority of the cities have been favorable.

I wish on behalf of the committee to extend to this Association an invitation to meet us at any of our meetings, to give us any information that you may have and to offer any suggestions that you may care to. It is a law that will cover all of the public utilities companies; there will be propositions affecting the water companies of the State, there will be questions that are in the particular knowledge of the men that are in the business. For your own safety, and in order to safeguard the public it will be necessary that the various Associations come forward with their information. After a bill is formulated and introduced at the next session of the Legislature public hearings will be held and we invite you to them either in your individual capacity or as representatives of this Association.

In these few words I have briefly outlined the situation. We have just commenced the work. We intend to pursue it farther and we hope to return a report at the coming session of the Legislature that will be a credit to this temporary commission and one that will be of benefit to the public at large.

Parkin: I would like to ask Mr. Holaday if upon invitation from the Board of Commissioners, it would be possible for the committee to stop at Elgin on their journey through the state. There are matters in most all cities, particularly at the present time, that we would like to go over with this committee.

Holaday: I will say that the cities to be visited are decided upon by Senator Dailey, who is chairman, but I think I am safe in saying that the committee would only be too glad to receive an invitation of that kind and it undoubtedly would visit your city. There was some talk at our last meeting about various cities to be visited and Elgin was one of the places mentioned.

NOTE: It was voted that the President-elect appoint a special committee to confer with the Legislative Committee on Public Utilities and also to take such action as they may deem necessary before the committee of the Legislature to whom bills on the subject may be referred.

PUMPING BY STEAM AND ELECTRICITY

BY E. MACDONALD.*

I have no paper to present at this time, although the program would seem to indicate otherwise; and I tried to get out of this entirely, but Dr. Bartow proved to be a very persistent sort of a fellow and would not take "No" for an answer, so I finally agreed to make a few remarks; and I am fortunate and perhaps you are unfortunate, for no agreement was made as to how much or how little I should talk or what the subject should be. So if too much time is taken just blame the Doctor for he is responsible for the whole trouble.

I believe I will talk about getting married. This is a very live subject and I will use as an illustration in favor of getting married the same argument often used by loving young couples, that two can live as cheaply as one.

Last year I undertook to get some information about the cost of pumping water by steam in the average town in Illinois. With that object in view I sent to a good many cities a letter of inquiry with a list of questions. The only cost question included was the cost of fuel and station labor required to pump one million gallons of water. When the answers were received I began to wish I had not started. The results were amazing, the city reporting the highest cost being more than 1200 percent higher than the one reporting the lowest cost on those two items. A good many of the results were not used as they were not complete; but there were about 35 replies which were very intelligible and from them I assumed an average town. I then undertook to compare those costs with the cost of pumping by electricity in a plant like the one at Lincoln. The result was this, I will not attempt to give very exact figures, it proved, that if the electric lighting plant were put with the water plant in such an average town, the price which it is now costing the water company to pump with steam, that is the cost of fuel and station labor, if paid to the lighting company, would amount to more than 5c per kilowatt hour for the current. It is a well known fact that lighting companies are on the lookout for

*Superintendent Lincoln Water and Light Company.

power and they will sell current off of their peak load at a much lower price than they would demand for lighting. That is, provided the power load is kept off of what is to them their lighting peak load. It is true the lighting company will make a price for such power uses considerably below 5c, in many instances with good profit to the lighting company. The question immediately arose, could the lighting company make such a contract with water companies. No. Because the water company is also liable to a peak load which is entirely different from the peak load of a lighting company. For this reason, a lighting company peak load can be estimated very closely and the time of its occurrence can be told in advance almost to the minute. The pumping station peak load, no man can estimate or tell when it may occur; how great it may be or how long it may last; in fact, it may never come, but the pumping station must be prepared for it. That peak load occurs when a dangerous fire breaks out. So the water company could not expect to obtain from the lighting company the same price per kilowatt hour given to manufacturers or other people, who will contract to keep off the peak load. In that case the water company would probably realize no economy, for they would still be required to keep the pumping station in good condition and have at least one man in attendance in case of fire during the evening hours; but on the other hand, supposing the lighting company had an excess of power and were willing to assume the liability of a double peak load, even then there would probably be no great saving; for the water company could not safely abandon its steam pumps, as there would be danger of an electric break down in time of fire, which would prove disastrous. So it seems that the only really economical method of pumping water by electricity, which would show a considerable saving over the cost of pumping by steam in the average town, would be to have a wedding. Marry the lighting station to the pumping station, make the two, one, with a good consulting engineer acting as best man.

The location of the pumping station is generally fixed by the source of the water supply, but electricity can be manufactured in the valley as well as on the hill top. Therefore the logical way would be to move the electric lighting station into the pumping house. The only extra equipment necessary would be to have a power pump; there would be a gain in the boiler capacity, and all the investment in one station building may be saved. If this arrangement were properly carried out it can be very readily figured that it won't cost anything to pump the water. Some smile at this statement but when you come to consider the saving in all ways, that is a fact. In the first place it is

true that modern lighting companies can produce power cheaper than the average pumping station. That is due I suppose to the fact that the lighting companies have been subjected to very sharp competition, with gas, gasoline and acetylene for lighting, and with steam, gas and gasoline for power. Lighting companies have been compelled by force of circumstances to abandon all their old machinery so that today we can hardly find a plant in the country but has been completely rebuilt during the past few years. Pumping stations that have no competition are still using the same machinery they have used for the last 15 or 20 years. Another reason why electric companies can furnish the power needed for pumping cheaper is that the pumping station labor may be entirely eliminated. I will simply add this, that at Lincoln we have proved by various tests, compared with the cost of operating two independent plants, that it does not cost anything to pump the water.

DISCUSSION.

Maury: I was very much interested, as I am sure all were, by Mr. MacDonald's characteristic and clear narration of his experiences. It would probably come as something of a shock to the average water works man to know that he could turn over his pumping to an electric company at 5c per kilowatt hour and save money by doing so. But I have no doubt that Mr. MacDonald's statistics will prove the conditions to be as he has stated them. One does find exceedingly poor economy in the average pumping station. It ought not to be so. The fact that there is *no* competition ought not to result in that *bad* condition; because the difference between loss and profit should be a sufficient incentive to work for better results than are shown by Mr. MacDonald's statement. It is a fact that an electric lighting plant, well equipped, could do pumping at a considerable profit at 5c per kilowatt hour, especially on a load more or less uniformly distributed throughout the 24 hours. I personally know it to be the case, because I have an instance in mind where a contract will soon be signed for pumping water by electricity at various plants distributed from 3½ to 6½ miles from the electric power station, with an aggregate use of power of about 100 kilowatts, and where the rate will not exceed 2c per kilowatt in December; and there is reason to believe that the rate at all other times will not exceed 1½c per kilowatt hour. The small size of the units in the average pumping station, as compared with the large units in electric power plants, militate against good economy; but Mr. MacDonald's figures, as he states, are based upon inquiries made of large plants as well as small ones, and the size of the pumping

engines in the large plants ought to be at least of such size as would give far better economies than those he has stated.

Cumming: To the remarks of Mr. MacDonald and Mr. Maury I will add a few words including some information regarding pumps. Mr. Maury says he knows of instances where electric lighting companies furnish power at 2c per kilowatt hour. At Jacksonville they furnish power at 2c per kilowatt hour. In Kansas they are pumping water with oil engines. They are likewise pumping with electrically driven pumps from other central stations at .8c per kilowatt hour. Oil engines are being used in the same field for pumping water from deep wells recently sunk. These wells are delivering from 1000 to 3000 gallons from a single drill hole with turbine pumps. The engines use residual oil as fuel and pump water against a head of 200 ft. for less than .4c per thousand gallons. The oil engines seem to be well worthy of careful consideration.

THE INSTALLATION AND SUCCESSFUL OPERATION OF A MILLION GALLON GRAVITY FILTER PLANT

BY JOHN M. KEEFER.*

The subject which I have chosen for a paper, today, is one that I hope will be of interest to the members of this Association and to cities of the state contemplating the erection of waterworks plants.

Macomb is a city of 6,000 inhabitants. For years we had been without adequate water supply. We were obtaining water from two sources: deep and shallow wells. As a result, we had to maintain two pumping stations at heavy cost in proportion to the amount of water secured, (120,000 gallons daily). The fuel cost was $5,000 annually and the cost of labor was $2,520.

The water from the deep wells (1,260 ft.) was so highly impregnated with chloride of sodium and other salts that it was unfit for steam or domestic uses. The water from the surface wells was good but the supply totally inadequate and constantly decreasing in quantity, while our needs were increasing.

The question of securing to our city an ample supply of pure water, suitable for all purposes, at a minimum cost, had been talked of for a number of years without definite action being taken. This was not lost sight of, on assuming the duties of my office (that of mayor of the city). How to accomplish it, was the question. The city was bonded to its legal limit. Fortunately, the legislature came to our relief by the enactment of a law changing the valuation of property from a one-fifth to a one-third valuation as a basis for taxation purposes. This had the effect of an enabling act and increased the city's ability to issue additional bonds. We were now in a position to submit to the voters of the city the proposition of issuing $40,000 waterworks extension bonds. A special election for the purpose was called. There was factional opposition to the proposition;—there always is to any public improvement; but the question carried by a vote of more than three to one.

The time had now arrived for active operation toward building

*Mayor Macomb, Ill.

a new waterworks plant. The committee (of which I was chairman) visited the city of Decatur, this state, where conditions were found to exist almost identical with our own. Valuable information in regard to the building of their plant was secured from the officials of that city.

I quote from my message, April 18, 1911, to the city council, as follows: "The gravity filter manufacturing companies of the country were asked to submit plans, specifications and estimates of cost for the installation of a million gallon gravity filter plant with a positive guarantee for the working of the same. Three of the most prominent filter companies responded, viz.: The Jewel Gravity Filter Co., of Chicago and New York; the Pittsburgh Filter Manufacturing Co., of Pittsburg and the Philadelphia Filter Co. The plans of the Pittsburgh company were accepted by the committee, theirs being the lowest and, by the committee, considered the best bid. The committee's action was unanimously approved by the city council. A contract was entered into and the building of the plant carried to a successful completion without one material change from the original plan adopted.

I confidently predict that our waterworks will become a large paying investment, the net earnings of which will meet all obligations incurred by reason of its building, such as interest charges, certificates of indebtedness, and the bonds as they fall due, without the cost of one dollar of increased taxation to the citizens of Macomb.

A large saving in the operation of the new plant, over that of the old, has already been established. The fuel cost under the old dual system was, in round numbers, $5,000 yearly, ($3,000 of which was paid to the Electric Light Company of Macomb, for electric power for pumping from the shallow wells, and $2,000 was for coal which was used to furnish steam for pumping from the deep wells) with a water supply of not exceeding 120,000 gallons, daily. Careful estimates have been made as to the fuel required in running the new plant. The cost will not exceed $1,900 yearly; a saving of more than $3,000, with an unlimited water supply. By building a tenant house at the pumping station for the use of the engineer in charge, an additional saving can be made of not less than $500, yearly, in the cost of labor in operating the plant: a total saving of $3,500, yearly. The following estimate of the possible net earnings of the new waterworks is made after careful investigation, based on the assumption that the consumption and sale of water is increased to 200,000 gallons, daily.

The estimated cost of pumping 250,000 gallons, daily, for one year, (this will allow 50,000 gallons for waste and use of city) together with interest on bonds, will not exceed the following amounts:

Interest on bonds, etc.	$2,000.00
Labor (which can be reduced)	2,260.00
Fuel	1,900.00
Chemicals	365.00
Repairs	500.00
Incidentals	500.00
Total	$7,525.00

It is reasonable to assume that the daily consumption and sale of water will increase to not less than 200,000 gallons or more, which, at an average price of 20c per thousand, would realize $40.00 daily, or $14,600 yearly. This would make a profit over interest charges and operating expenses, of $7,075 yearly. With an increased sale of water, a larger profit would be secured.

We have in our city, 105 hydrants. This number will soon be increased to 125. The usual price charged for each hydrant in other cities is from $40 to $50. At $40 each, 125 hydrants would cost $5,000, yearly, if the city paid for them. This $5,000 saved the city, should be credited to the waterworks.

What does the saving of $3,000, yearly, on fuel mean?

The cost of the new waterworks plant is, approximately	$46,000.00
The interest charge to be paid on this indebtedness as it falls due, will not exceed	30,000.00
Making a total indebtedness to be met within the next 30 years	$76,000.00

The saving of $3,000, yearly, in fuel for 30 years, aggregates the sum of $90,000. Even though we do not sell one gallon more water, $90,000 will pay the principal and interest on cost of plant and leave a balance to its credit of $14,000. A saving of $500, yearly, in the cost of labor, for 30 years, means an additional saving of $15,000."

Our new waterworks plant has been in operation one year with the result that all that was claimed for it has been more than realized. The cost of fuel for the year was $1,380 against $5,000 paid under the old dual system, a saving of more than $3,600.

After May first of the present year, the waterworks system of our city will be operated by two men on salaries amounting to $1,800 per annum, a saving in labor of $720, yearly; a total saving in favor of the new as against the old way of obtaining our water supply, of $4,320, yearly.

The freedom from typhoid fever and kindred diseases has been most marked. Never in the history of our city have we been so immune as in the past year.

Our present source of supply is Crooked Creek, and sometimes called Lamoine River; it is distant one and one-third miles from the center of our city. In flood time, it assumes the proportion of a small river; at this stage, our supply is largely surface water; in the lower stage it is fed by springs. The minimum flow during the past dry season was three and one-half million gallons, daily.

A dam of reinforced concrete has been built across the stream, of sufficient height to raise the water level 5½ feet above the bed of the creek, backing the water up stream for quite a distance and creating a reservoir of several million gallons capacity. From this reservoir the water flows, by gravity, through an 18-inch pipe into a receiving well, distant 175 feet; the depth of this well is 20 feet; its diameter, 10 feet; there is a partition wall 5 feet high. The water from the intake pipe discharges on one side of this wall; after filling the space it flows over the top to the other side, leaving solids behind, and is drawn by centrifugal pumps located in pumping pit in building, 150 feet distant, and by the same operation forced into the mixing chamber where the chemicals, by an automatic device, are added. Thence, by gravity, it flows into the settling basin, which has a capacity of 175,000 gallons, where it remains from 4 to 6 hours.

The system by which the water is purified is a mechanical filter system, three steps being required in the process, as follows: coagulation, sedimentation and filtration.

During the time the water remains in the settling basin, coagulation takes place. About 75% of the impurities being precipitated to the bottom, thereby relieving the filters of heavy bodies which would quickly clog them and require frequent cleansing of the beds and unnecessary waste of water for washing.

The coagulant used is sulphate of aluminium, (fifter alum) which acts on the same principle as the white of an egg acts in clarifying coffee. Under certain conditions of the water, where typhoid and other germs, deleterious to health are found, hypochlorite of lime is used in addition to the alum and is added after the water has passed through the sedimentation basin on its way to the filters. The final process is the passing of the treated water through the filter beds.

The filters are constructed of reinforced concrete of proper dimensions. Covering the bottom of the compartment is a system of strainers of which there are 800 in each filter. Screwed into the 1½-inch iron pipes and equally distributed over the bottom of the filter, these pipes

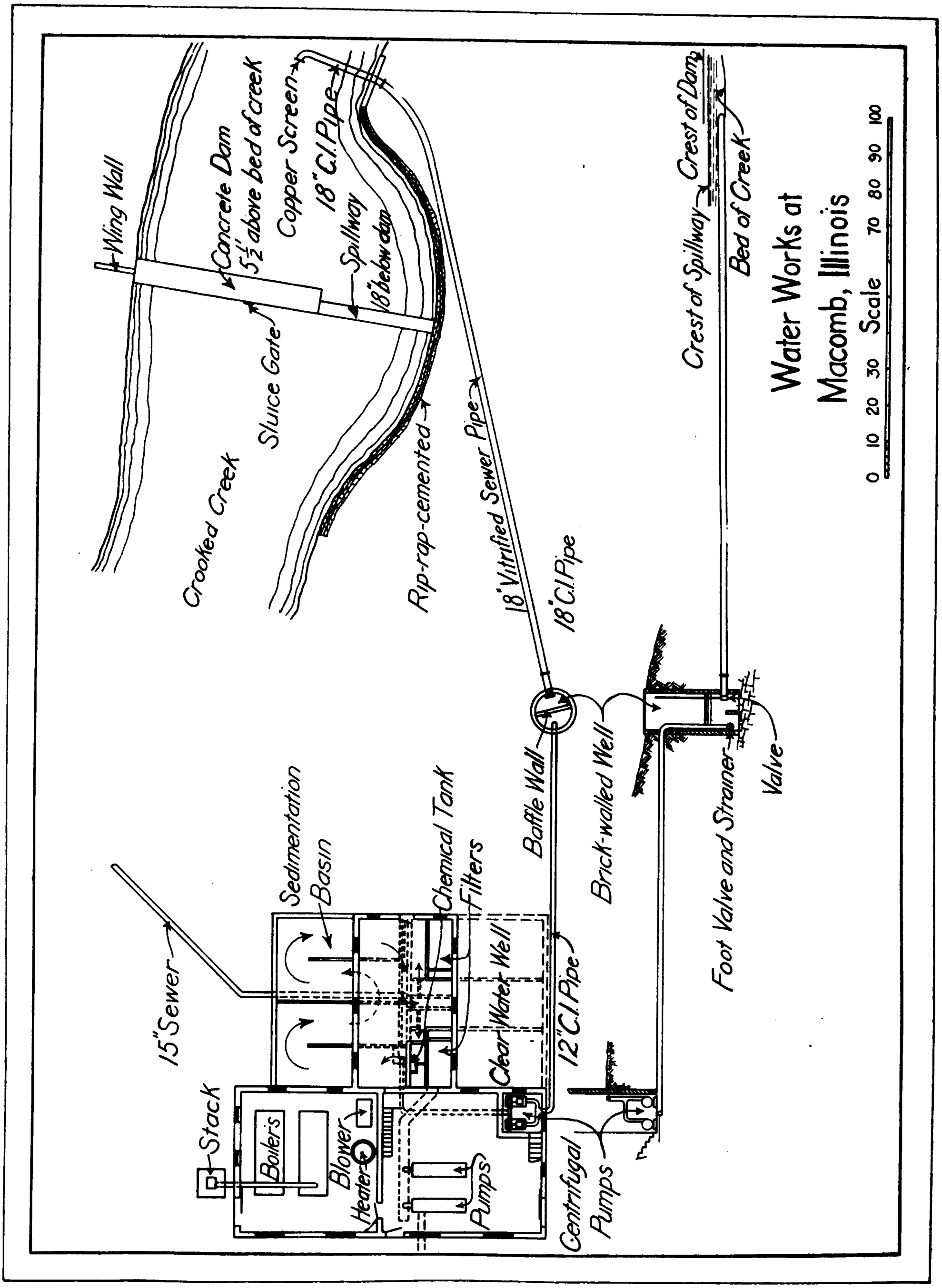

Fig. 1. Plan of Water Works at Macomb, Illinois.

discharge into one central drain. On top of these strainers is placed, first: 8 inches of a washed gravel about the size of navy beans; then, 8 inches of a finer gravel; lastly, three feet of a sharp flint sand of uniform size.

The filters are now ready to receive the treated water, which flows into them, by gravity, from the sedimentation basin. After passing through the filter beds the water is directed to the pure water well, or reservoir, (which has 150,000 gallons capacity), ready to be pumped through the mains and distributed through the city for use. 12-inch, standard cast-iron pipe, 6,600 feet long leads from pumping station to the city.

The water is clear, sparkling and pure, suited for all purposes, domestic or steam. The analysis of the filtered water shows it to be pure. There is not one well of water in our city, of all those tested,

Fig. 2. Exterior of Filter Plant at Macomb, Ill., Showing Settling Basin.

that compares with the filtered water, and as a rule, we have found the water taken from wells, unfit for use. Clear water, as drawn from wells, does not necessarily mean pure water.

Our plant is in duplicate, so far as its machinery and mechanical parts are concerned. Should one part get out of order we have the

other in reserve. Our pumping engines are of the compound duplex type. For a million gallon plant, I think them preferable to the high duty pumps, being more simple in construction. Our pumps are each guaranteed to pump 1,000,000 gallons, daily, delivered into a stand-pipe with 240 feet elevation ½ mile distant.

A new stand-pipe to hold 100,000 gallons with height of 140 feet

Fig. 3. Interior of Filter Plant, Macomb, Ill.

will be erected on Cemetery Hill. A stand-pipe of the above capacity and height, with hemispherical bottom and 12-inch connecting pipe, would furnish greater pressure. It would not be necessary to pump during the night; a saving of fuel would result. Should a fire occur, the supply of water and pressure would be ample until the pumps could be put in operation. A 12-inch connection in mains has been provided at the proposed location of the stand-pipe. The cost of stand-pipe such as I have mentioned would be $6,000, in place.

Our pumping station is located on the banks of the creek 24 feet above its bed and above high-water mark. The building is constructed of reinforced concrete and brick, the floors of cement. A feature of the building is the concrete walls of the filters, the clear water reservoir

and sedimentation basin which are used as part of the foundation for a brick superstructure. The building is steam heated, and as comfortably heated as any well heated place of business. Our system of lighting will be electric. When it is placed in position, we have room and power ample for installation of an electric light plant to light our city. This question is under consideration.

The amount received from sale of bonds was $40,920, realizing a premium of $920. The legality of the issue was passed on by Mr. Woods of the firm of Woods & Oakley of Chicago. The bonds bear

Fig. 4. Pumping Station, Macomb, Ill.

4½% interest. To complete payment for the new waterworks plant, it was necessary to issue $4,900 of certificates of indebtedness bearing 5% interest. These have no legal standing, except against the waterworks fund. They will be retired by the net earnings of the plant before January next, one year before maturity.

The plant is located in a beautiful twenty-acre tract of wooded land converted into a city park. This is quite a pleasure resort in summer for outing and picnic parties. Electric lights will be distributed throughout the park.

Ours is a model, up-to-date concrete plant, of which the citizens of Macomb feel justly proud. We invite the officials of other cities who contemplate the building of waterworks, to visit ours. We are always ready for inspection and will take great pleasure in showing visitors our plant and explaining its workings to them.

DISCUSSION.

Bartow: I have already had an application from a mayor of another city for a copy of this paper for use in showing the people of his city what can be done and am expecting some good results from the example set by Macomb.

Jahns: I would like to ask with reference to the settling basins that were described. The capacity, is that the amount that it contains in flowing through or are they filled and allowed to settle and pumped from there subsequently.

Keefer: The water flows from mixing chamber into the settling basin, entering at the bottom of the basin; the basin is 14 feet deep and has a capacity of 175,000 gallons. It requires 4 hours' pumping, with one pump, to fill it, so that the water first entering the settling basin remains there 4 hours before it flows into the filters. When pumping stops, the water ceases to flow. The basin is always full of treated water; the moment the pumps are put in operation, the water commences to flow into the filter beds.

After the water has passed through the sedimentation basin on its way to the filters, hypochlorite of lime is added to it. We use from 5 to 10 pounds of hypochlorite of lime to the million gallons of water, according to the condition of the water. This is upon the recommendation of Dr. Bartow, and has given splendid results.

FURTHER TESTS ON THE REMOVAL OF IRON FROM A DRIFT WELL WATER

BY ARTHUR N. TALBOT.*

In the paper given last year on the experimental work done at the plant of the Champaign and Urbana Water Company a report was made of the results of the tests for removal of iron using thorough aeration, preliminary filtration through gravel, and final filtration through sand. The water used was from a single well. The results appeared to show that while the preliminary filtration through gravel removed a considerable portion of the iron and thus relieved the sand filter from a part of its load the use of the preliminary filters did not result in a better effluent nor did they materially extend the length of time between the washings of the sand filter. It appeared desirable to continue the experiments using raw water from the group of wells and to find if high aeration is necessary to satisfactory operation, and also to learn what effect more vigorous washing has in long continued use of the filter.

By the present arrangement of the plant the wells discharge directly into a small receiving reservoir, and there is some aeration where the water is discharged into this reservoir. There is a second reservoir for service storage use. To operate a filter plant the raw water must be raised to a higher level than that of the present receiving reservoir. It seems advantageous to continue the use of this reservoir as a receiving chamber, as this will permit a variable distribution from the well system when the filters are operated at a uniform rate, and a single pump will raise the water the additional height more economically than would the well pumps. Experiments were therefore made by taking water from the receiving reservoir through a centrifugal pump and discharging it into the experimental rapid sand filter without further aeration. The same general apparatus was used as in 1910, but without the preliminary filters. A filtration rate of 125,000,000 gallons per acre per day was used in most of the runs. There was a larger provision for wash water. The amount of iron in the water

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remained quite constant and was the same as in the water from the well previously experimented with, about two parts per million. The dissolved oxygen in the water taken from the reservoir averaged between four and five parts per million, say 50% of saturation at the temperatures used.

The purification effected was much the same as in the earlier tests; under normal conditions from 0.1 part to 0.3 part of iron per million remained in the effluent. At the end of long runs the iron ran up to higher amounts, but a thorough washing of the filter brought it back to the normal conditions.

The smaller amount of dissolved oxygen in the water, as compared with the fully aerated water used last year, seemed not to affect the efficiency of the filter. In general there was very little loss in dissolved oxygen during passage through the filter. At times the dissolved oxygen in the effluent was almost entirely exhausted. It seems very evident that this loss of oxygen was not due to the amount required for the oxidation of iron, but to the growth of organic matter in the filter itself.

It does not seem probable that the function of the filtering material is to act simply as a surface strainer, for filtration of the water through filter paper gave an effluent with 0.8 parts per million of iron while the sand filter at the same time was removing all but 0.4 parts per million. With the coarser sizes of filtering sand a greater depth of filtering material will be necessary, but the coarser material can be washed more easily. Sudden changes of rate will cause deposited iron to be washed out of the filter when coarse sand is used. Crenothrix seems to grow more rapidly in the finer material. A more rapid flow of wash water may be used with coarser material without throwing the sand out. The problem seems to be to select a sand fine enough to give a satisfactory effluent with the changes in rate likely to occur in the operation of the filter plant, and which will be coarse enough to be washed easily.

The few tests which were made at higher rates than 125,000,000 gallons per acre per day indicate that the filter may be operated at higher rates with a good quality of effluent but that the filter will have to be washed after the same quantity of water has been filtered.

In the earlier tests an amount of wash water only sufficient to give a rise in the clear of one foot in 130 seconds was available. In the later tests a wash giving a rise of one foot in 50 seconds was obtained. Under this more vigorous washing the filter deteriorated much more slowly than before, though there was some deterioration. A renewal of normal conditions was obtained by a particularly thorough wash.

Bleach was used several times at the washing period. It had the effect of lengthening the run but it did not improve the effluent.

Several attempts were made to determine the amount of iron in the wash water, and it was desired to know whether the wash water might be used again. A great deal of suspended matter other than iron was found. Little subsidence was found in a few hours time. It was seen that further use of the water was impracticable.

A test was made by allowing the filter to stand idle and then blowing air through it to dry out the sand bed, but this did not increase the length of the next run materially. A noticeable feature of the subsequent run was that a longer time elapsed after starting the run before the effluent became satisfactory.

The results of these tests are encouraging for the removal of the larger part of iron by rapid filtration without the use of chemicals. The water company is planning to put in a plant during the coming summer.

The immediate work connected with the tests was done by Mr. Arthur L. Enger, University of Illinois, class of 1911 in Municipal and Sanitary Engineering.

SMALL FILTER PLANTS

BY W. W. DE BERARD.*

To filter or to otherwise purify all drinking waters obtained from surface sources is the goal toward which all sanitary engineers are striving today. With few exceptions, every mountain stream, lake and river in this country now needs or shortly will need to be treated in some way to make these waters safe for use as water supplies. The time is fast disappearing when cities will tolerate annually recurring typhoid epidemics traceable to polluted public water supplies

You all know of the large purification plants in such cities as Minneapolis, Grand Rapids, and Flint, but not many of you are familiar with the small plants in Temple, Texas, Miles City, Montana, Fairfield, Iowa, and Port Clinton, Ohio. There are literally hundreds of these little towns ranging from 2000 to 10,000 inhabitants that are waking up to the advantages of hygienically pure, and also physically attractive drinking water. Just as much thought and just as many devices are needed to filter water for the smallest town as for Philadelphia or Grand Rapids, nay more, for the little plant must be made as near fool-proof as possible, inasmuch as it will get a minimum of attention.

To remove disease germs and to improve the appearance of a water is the function of the filter. Sand is used almost universally as the filtering material. Various types and kinds of containers hold the sand. Methods of cleaning the sand, getting the water to the sand and away from it are varied to suit the local conditions and have to do more or less with the supply, but after all, in filtration as in some other things, it is sand that does the work.

To most men sand is sand. A sand specification, a sand curve and a sand analysis is all Greek to the ordinary contractor and to many engineers. Sand for one type of filter is not suitable for another type and more than one filter plant is not giving today the efficiency it could, simply because the sand is not the right size and the hydraulic properties of sand are not understood. Limits represented by sand in use,

*Western Editor Engineering Record, Chicago.

range from 0.2 to 0.4 mm. effective size, with uniformity coefficients from 1.5 to 3.0. For rapid filters the size is somewhat larger and the uniformity coefficient lower. In any kind of a filter sand must be washed and the more uniform it is the less stratification will occur and the easier will it be to obtain good results.

Experiments made to determine the height through which sand

Fig. 1. Interior of 1,000,000 Gal. Plant, Middletown, Pa. Two Units 10x18 ft.

grains of different size will rise in an upward flowing stream of water have been very carefully conducted by our friends the mining engineers. Waterworks engineers also have carefully studied the subject; thus at Oakland, Cal., in some experimental filters numerous tests were made along this line on typical filter sands.

A typical rapid filter consists of a rectangular concrete box 12 ft. deep, filled with 30 in. of 0.37-mm. sand, supported by 6 to 8 in. of graded gravel resting on and surrounding a collector system of which there are any number of types from the perforated pipe to the slotted strainer head and punched sieves. Fig. 1 shows the interior of a

1,000,000-gal. plant at Middletown, Pa. There are two units, 10x18 ft. in plan with a single wash water trough.

Various means are used to disengage the coagulated material from the sand grains. Mechanical agitation with rakes was used in the older type of wooden tub filters. Air under about 4 lb. pressure applied through the same collector system or through a special air-pipe

Fig. 2. Interior of Filter at Kansas City, Ks., Showing Gutters and Screens Over a Portion of the Floor.

system is now used in many filters. Doubling the rate of applying the wash water or the "high rate wash," as it is called, has proved very successful at Cincinnati and New Orleans.

The jet action of the water issuing from the underdrain opening does not reach to the surface of the filter and the dirty sand. Having this in mind experiments were made at Oakland with an auxiliary discharge of wash water through a perforated-pipe system suspended immediately above the sand during ordinary operation. During washing the sand rose around the pipes and the jets played directly on the dirty

sand grains. Using practically the same amount of water, it was possible to scour the sand grains perfectly clean.

Openings in the underdrain system must be small enough to produce a resistance sufficient to distribute the wash water evenly to all parts of the filter. Formerly little attention was paid to this point in the design of underdrains. It is, however, the controlling feature, just as it is necessary to increase the resistance at the separate lamps

Fig. 3. Inside of Rapid Filter, Harrisburg, Pa.

on an electric-light circuit to obtain an even distribution of current to each fixture. Areas of opening up to 2 per cent of the filter area have been observed in some of the older inefficiently-washed filters, whereas for ordinary rates of washing at 10 to 12 in. vertical rise per minute, the area of the strainer opening now considered proper is 0.2 to 0.3 per cent. Fig. 2 shows the interior of a filter at the plant at Kansas City, Kan. Part of the screening over the ridged under drain system was not placed when the photograph was taken. This is a "high rate wash" plant. Note the curved weir edges to reduce head.

Gutters to carry off the dirty water should not be far apart, otherwise the suspended matter rising farthest from the gutters will not

have time to travel the horizontal distance to the gutter during the 5 to 10-min. washing period. Weir action should be obtained the whole length of the gutter, for the same reason. Further hydraulic investigations to determine the proper size of gutter to run nearly full and still maintain the weir action could well be undertaken. Few gutters are

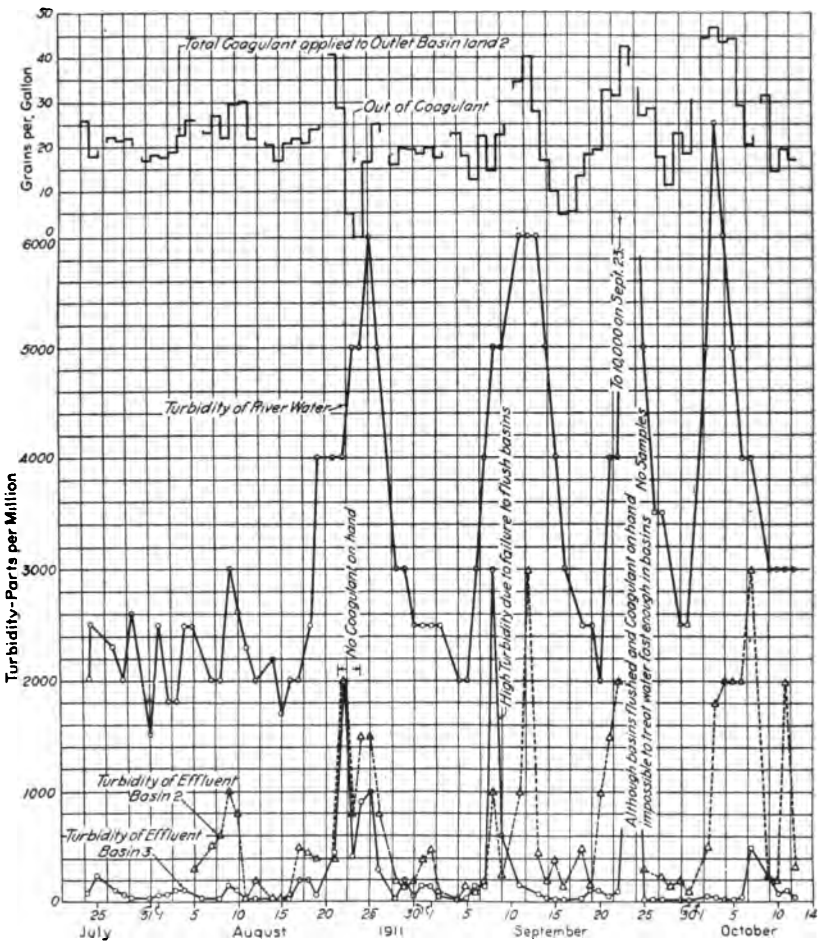

Fig. 4. Results of Treating Missouri River Water at Kansas City, Ks.

able to handle the maximum amount of water for which they were designed without flooding. Fig. 3 is a view of one of the Harrisburg filters before placing sand. The gutters are spaced on 8-ft. centers. On

the underside of the $1\frac{1}{4}$-in. laterals spaced on 6-in. centers are 7-32-in. holes, 3 in. center to center. Air and water both issue from the same system.

Inefficient washing is indicated in impaired bacterial results and finally by the inability to remove turbidity. Mud balls appear on the surface and hard spots of sand caked with suspended matter together with coagulant are found.

The settling basin and coagulating tanks comprise the preliminary treatment of water for rapid filters, a process upon which may depend the success or failure of the whole plant. If the water contains a

Fig. 5. Tanks and Orifice Boxes at So. Milwaukee. Alum on Left and Hypo on Right.

turbidity running in the thousands for months at a time, with occasional rises to 10,000, as in the Kansas City (Kansas) plant, see Fig. 4, a much longer time must be given than at Little Falls, N. J., where turbidities in the hundreds are unusual. If the water came to the Kansas City filters in a well coagulated condition, with a turbidity not greater than, say 60 to 75, the filters almost invariably produced a

water absolutely free from turbidity, sparkling in appearance due to the liberated CO_2, and with a bacterial content of 100 per c.c. or less.

Chemicals are usually applied to the water in solution. For this purpose many ingenious devices have been designed and are in use. The simplest rig and perhaps the one oftenest used is a float-controlled orifice box fed by gravity from a solution storage tank, such as is shown in Fig. 5 of the South Milwaukee plant installed by the American

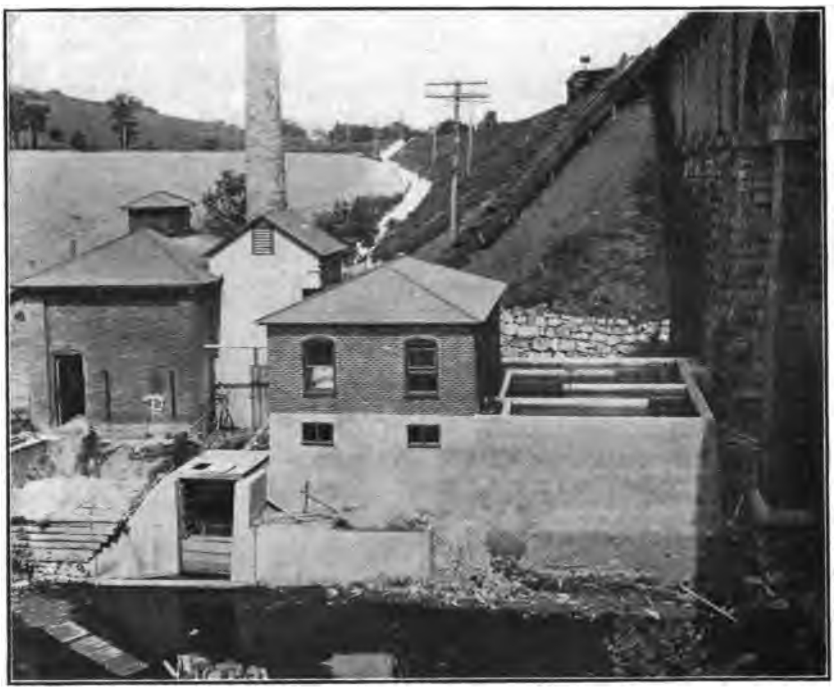

Fig. 6. Baffled Basin, Around-the-End Type, 600,000 Gal. Plant, Beaver Creek, Pa.

Water Softener Company. It is highly essential that the coagulant supply be regulated to the needs of the incoming water and that each gallon of water gets its share. This important vital part of the rapid filter system receives much careful attention on the part of the designer, as it should, but on the part of the operator there is nothing that causes him more trouble and to which he is likely to give a minimum of care. By hourly readings of a scale on the solution tank graduated in pounds,

a simple three-figure calculation enables the operator to know at what rate the water is being dosed.*

It is good practice to have everything in connection with the coagulant apparatus in duplicate and the piping of some non-corrosive metal

Fig. 7. Settling Basin and Filter House, 2,000,000 Gal. Plant, Temple, Texas.

arranged to permit applying the solution at various points in the settling basin before the water reaches the filter.

Bound up with the coagulation of a water is the question of settling basins. Theoretically, entrance of water to a settling tank should be at one end through a perforated wall with sufficient loss of head to make each opening deliver its share of water to the end of a rectangular basin in which the forward velocity should bear a definite relation to the falling properties of the suspended material. If this bar of water would then move forward uniformly, we would have ideal conditions.

A few basins are now built on this principle, among which may be noted those at Minot, N. D., and Evansville, Ind. In many basins no

*See Eng. Rec. July 25, 1908.

attempt is made to spread out and reduce the velocity of the incoming water. Baffles of various kinds are inserted to break up short cuts of the water from the inlet to outlet, as at Beaver Creek, Pa., shown in Fig. 6 and at Temple, Tex., shown in Fig. 7, plants installed by the

Fig. 8. General View. So. Milwaukee Filter Plant.

Pittsburg Filter Manufacturing Company. Some engineers do not believe in baffles and rely entirely on spreading out the supply at one end of a long, fairly deep basin and removing the water from the opposite end, through submerged orifices or over weirs. This method is used at Cincinnati, Harrisburg and Kansas City, Kansas. At the South Milwaukee 1,500,000-gal. plant, Fig. 8, water enters the coagulant basin through a perforated concrete curtain wall to distribute it over the whole section. The basin is the rectangular flat topped structure in the center of the photograph.

Results obtained by filters may be expressed in many ways but the most comprehensive is by chart. If it is desirable to study a particular filter closely, a chart such as the one shown in Fig. 9 is worth while. This was used in the filtration investigations for the Peoples Water

Company at Oakland, Cal. The plotting gives one a fund of correlated information otherwise unobtainable without turning dozens of pages and comparing column after column of figures. The method is not practical, of course, for every day work, and something along the

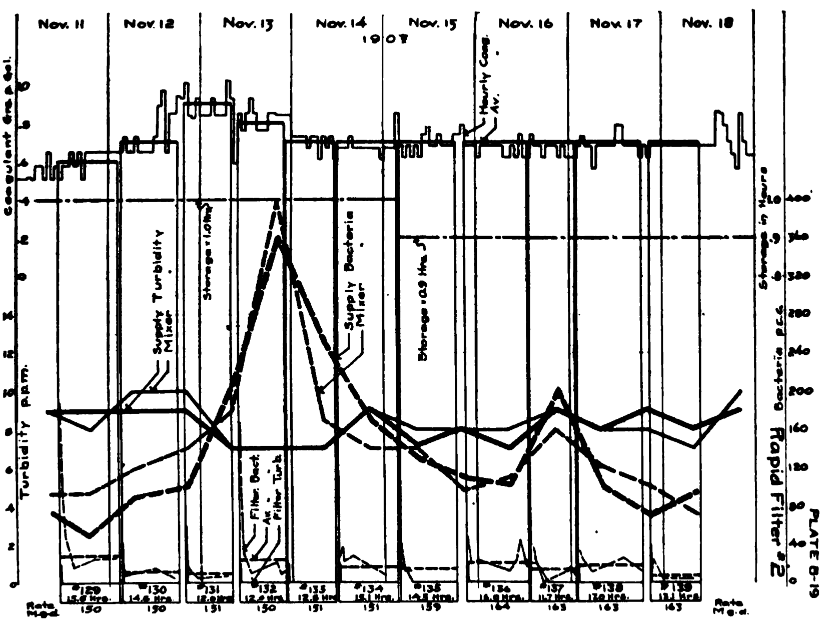

Fig. 9. Example of Comprehensive Plotting of Results from Experimental Filter, Oakland, Cal.

line of the chart shown in Fig. 10 for the Rock Island plant may be used with profit. The most noticeable thing in this chart is the appearance of B.coli after the bleach was discontinued.

Importance of the operation of a plant upon which the public welfare depends should not be overshadowed by an overzealous enthusiasm about the design and construction. Filter plants will not run themselves, make them as fool-proof as we may. A false sense of security may be engendered in the mind of the consumer by the increased amount of his water tax which is explained to him by a grandiloquent reference to "our purification plant." Assurance of all of the benefits of pure water can only be obtained when the filters are designed to meet the conditions, constructed in a conscientious manner and operated day after day intelligently. Too often a modern plant is turned over to the tender mercies of an already overworked

superintendent entirely ignorant of the delicate mechanism the high-priced sanitary engineer has constructed. If the superintendent is conscientious, resourceful and has the time, he very soon becomes expert in handling his plant, but he should be given every advantage of the aid latter-day methods of analysis can render, as well as friendly ad-

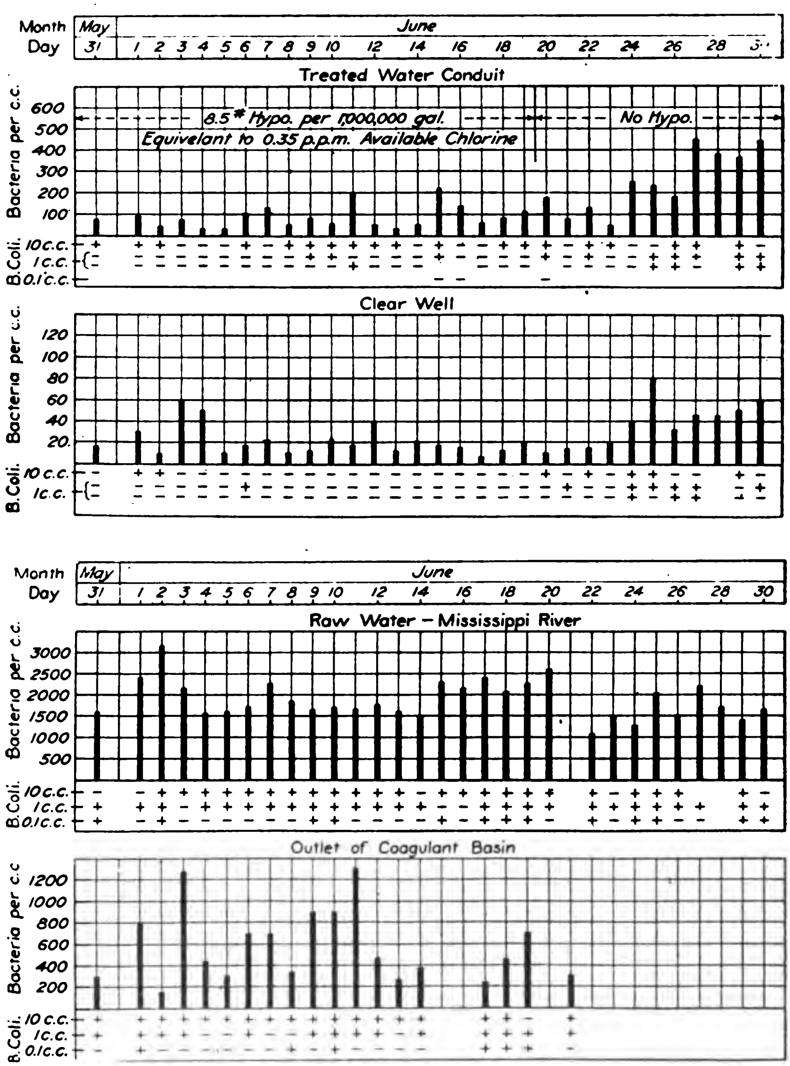

Fig. 10. Bacterial Record for June 1911, Filter Plant, Rock Island, Ill.

vice from the constructors. Put the plant in charge of a technically trained man is the best way. At large plants this is done, but it is not financially feasible with small towns. State Boards of Health can only render periodical service. Recently the Illinois State Water Survey has been urging the establishment of laboratories at all plants and has been instructing the superintendents of the smaller ones how to make turbidity readings, colony counts and a few of the more important tests from which they will know what their plants are doing.

DISCUSSION OF NEW DEEP WELLS AT JOLIET, ILL.

T. E. Savage (by letter): I was interested in the troubles that were experienced in putting down the deep wells at Joliet. It was a matter of surprise that the Maquoketa shale had given them trouble by caving. This shale is usually so hard, when dry, and so plastic, when wet, that it seldom caves or slumps much as a hole is put down through it.

On the contrary, the St. Peter sandstone is often soft and incoherent, except at the surface where it has become "case-hardened". The grains of this sand are usually much rounded. In the presence of water these round, unconsolidated grains move readily on one another like quicksand. As a consequence, such difficulties as Mr. Stevens describes are frequently encountered in boring through the St. Peter sandstone.

As the well at the intersection of Canal and Division streets, in Joliet, was put down the company saved an excellent sample of the rock material from every five feet in depth. From a study of these samples, the character and thickness of the different formations that were penetrated from the top downward were found to be as follows:

	feet
Surface material	
Gravel	3½
Niagara limestone	
Gray to yellowish dolomite	232
Marquorceta shale	
Dark to bluish shale	90
Galena-Trenton limestone	
Gray to yellow dolomite	205
Dark gray, fine-grained dolomite	90
St. Peter sandstone	
White to light gray sandstone	200
Lower magnesian limestone	
Gray, fine-grained dolomite	245
Gray, sandy dolomite	60
Gray dolomite	210
Potsdam sandstone	
Gray to white sandstone	235

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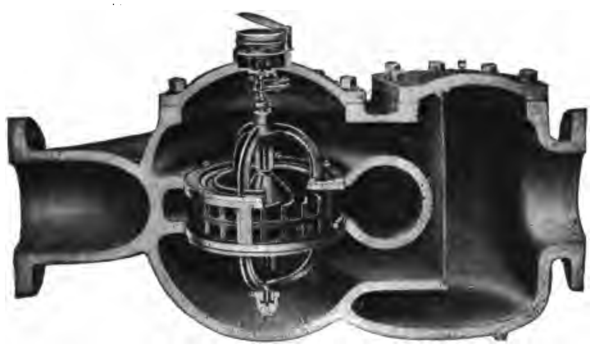

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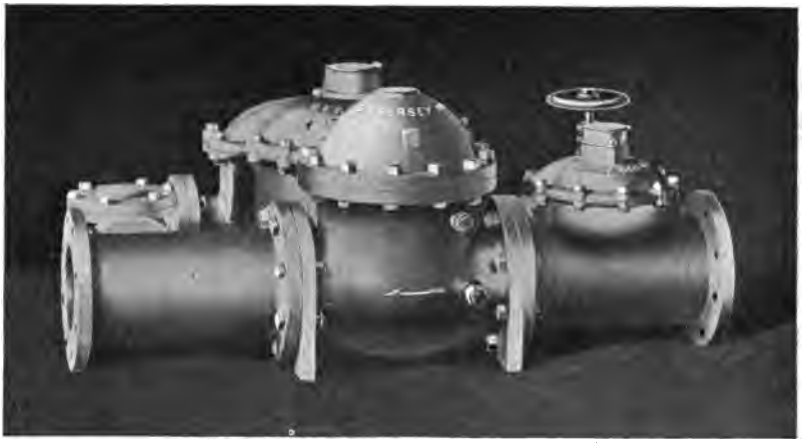

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No. 6. Chemical and Biological Survey of the Waters of Illinois. Report, September 1, 1906, to December 31, 1907. 88 pp., 3 cuts, 9 pl. 1908. (Out of print).

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No. 8. Chemical and Biological Survey of the Waters of Illinois. Report for 1909 and 1910. 150 pp. 1911. Price 75 cents.

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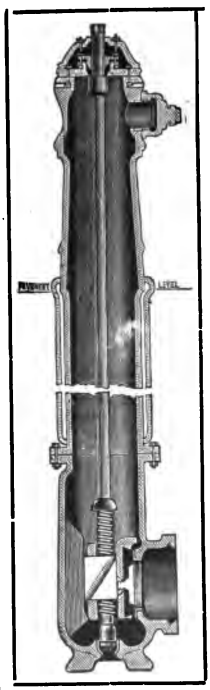

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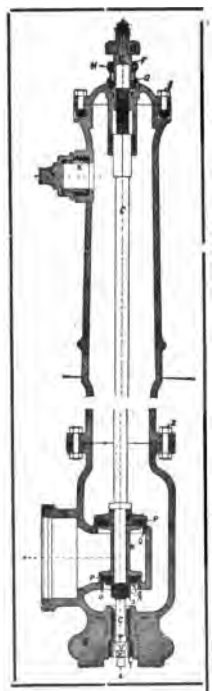

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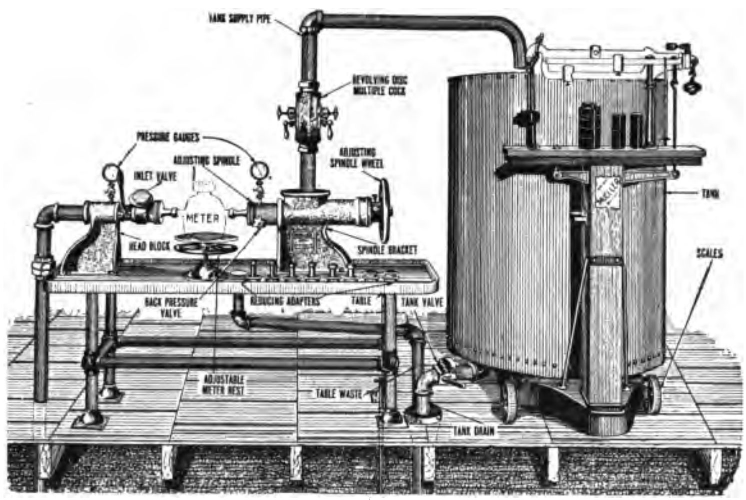

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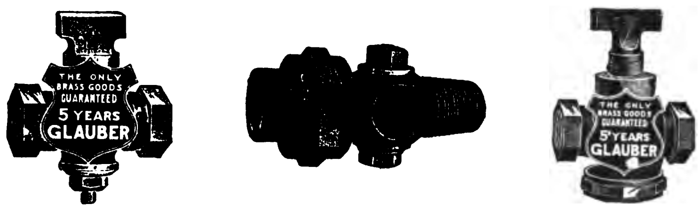

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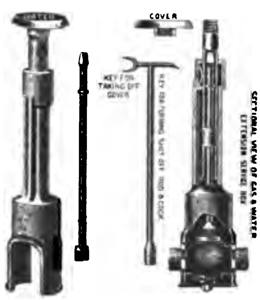

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